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THE HORSE FOOT CRAB.

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It is proposed to give some results of a summer's study on the incubation of the eggs of the Horse Foot Crab, and to connect those results with observations made in an acquaintance of several years with the animal in its native haunts, in the hope of thereby furnishing something towards a life-history of the species.*

Among systematists this crustacean is known as *Limulus Polyphemus*. It bears also the popular names Horse Foot Crab, Horseshoe, and King Crab. In this article these names will be used as convenience may suggest.

The King Crab delights in moderately deep water, say from two to six fathoms. Except in the case of the very young, which are probably carried thither by the tidal flow;

*In October, 1869, the writer read a paper before the Zoological section of the New York Lyceum of Natural History, under the title "A Contribution to the Natural History of the King Crab," which contained the notes taken during the summer's investigation alluded to above. The article now appearing in the AMERICAN NATURALIST is taken mainly from that paper. — S. L.

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it never seeks the shallow waters, unless for the purpose of reproduction. It is emphatically a burrowing animal—living literally in the mud, into which it scoops or gouges its way with great facility. The anterior edge of its enormous cephalic shield is not unlike in form the sausage, or mince-meat knife of our kitchens (Pl. 3, Fig. 12). The upper shell of the animal is composed of three parts—the forward shield, which is greatly the larger, the posterior shield, and the long bayonet-shaped spine, or tail. In the burrowing operation the forward edge of the anterior shield is pressed downward, and shoved forward, the two shields being inflected, and the sharp point of the tail presenting the fulcrum as it pierces the mud, while underneath the feet are incessantly active, scratching up and pushing out the earth on both sides. There is a singular economy of force in this excavating action, for the alternate doubling up or inflecting, and straightening out of the two carapaces, with the pushing purchase exerted by the tail, accomplish both digging and subterranean progression. Hence the King Crab is worthy to be called the Marine Mole.

The Limulus is carnivorous. Its food is the soft nereids, or sea worms; so that not only in its mode of burrowing for concealment, but also in its method of procuring food does it resemble that little burrowing mammal of the land. It is sometimes found held in a strange durance, with a limb entrapped between the valves of the quahog, or round clam, (*Venus mercenaria*). It is a pitiful sight to behold—a galley slave with limb confined to ball and chain—"as far from help as limbo is from bliss." The explanation is easy. The quahog too is a burrower, and Limulus has seized the projecting syphon of the mollusc, which being suddenly withdrawn, the less agile claw is jerked between the valves, and the same are closed. This, of course, would effectually entrap the limb. But here occurs just this strange fact, that a lobster or a crab would not long be held in such durance, but would give their custodian leg-bail; that is, would cast

off, and desert the imprisoned limb, and in due time would reproduce the lost member.

The position of the mouth, and the masticating process are so peculiar, that a description should not be omitted. The King Crab has six pairs of feet; although by some, those constituting the extreme anterior pair are called antennæ, being greatly shorter than the others. The four pairs between this first pair, and the last pair, have a functional structure differing from the anterior and posterior pairs. Of these four pairs, the basal joint, or haunch, of each limb is flattened and smooth on each side, as though they were a series of plates intended to work upon each other, as the keys of an organ under the fingers of the musician. The external edge of each is rounded, and beveled like the edge of a carpenter's chisel. Thus these flattened haunches lie against each other, their rounded edges directed backward at a considerable angle. The beveled edges (which are the exposed parts) of these projections are covered with very sharp incurved spines, overhanging and pointing into the oral aperture; for it is between these four pairs of spine-clad haunches that the creature's mouth is situated. Each of these basal spines is articulated, and is set in the crater, or cup, of a little teat-like prominence. These then, are the true jaws of the animal's mouth; and as there are four pairs of these manducatory joints, the creature's mouth is set in a line between eight jaws. These spiny teeth have, by their articulation, an amount of mobility in their little pits, which is eminently serviceable and preservative. Of these chewing teeth, though the number is variable, an individual can scarcely have less than one hundred and fifty.

Wishing to see what their food might be, and how they eat it, I placed a specimen, hatched the preceding summer, in a small aquarium, and supplied it with plenty of fresh and tender sea lettuce (*Ulva latissima*). But this sea salad remained untouched, although the young Limulus had no other fare for three weeks. In fact, famishment had rendered it

literally diaphanous. I then tried animal food. Having opened a live quahog I routed the little fellow from his hiding place in the sand, and gave it a morsel of the clam. It was ravenous, and fed only as a really hungry being could. Though using the round clam principally, I gave it other food at different times. Any mollusc was acceptable, if only sufficiently tender. It even ate beef; but not with the relish of the mollusca. This I observed, that being well fed it never would eat carrion; although what it would do if impelled by hunger I cannot say.

As yet I had not *seen* the eating. This was also hidden by the carapace. I was now very anxious to witness the feeding process. The first step was to put the animal on a long fast, and thus to secure a good appetite. This done, a bit of clam was dropped before the hungry crab, which was instantly drawn under with its claws, when I immediately turned it over, holding it with the abdomen against the glass side of the tank. It was kept in that position for full five minutes, the eating process being easily witnessed, and the manducation quite satisfactorily observed. The performance is certainly a very curious one. The animal being in its natural position, the food is held immediately under the mouth by the claws, or nippers, of the posterior pair of jawless feet, aided, if necessary, by some of the others. The basal joints, or manducatory haunches, then begin an alternating motion of these members upon the food, by drawing one of the spiny or rasp-like joints against the opposite one of the same pair, the food of course being between the two. This chewing by means of these opposing rasps, reminded me of the hand-carding process, in which the card held by the right hand is brought towards and against the one held in the left hand, the wool being between; when the right hand card is held still, and the left hand duplicates the motion, and so on. The fine particles rasped off by the incurved teeth pass into the mouth. It will be readily seen that food so finely chewed before it passes into the digestive

apparatus would afford but a poor chance to the investigator who sought its nature by use of the knife. Of the large number that I have opened of adult specimens, I never found anything to tell me on what they fed; and not until by actual experiment, above described, did I know whether Limulus was vegetarian or carnivorous.

The exuviation of the King Crab is performed several times during the first year, and at very short intervals. How many I do not know, as that must vary according to the time of hatching. But I think the young produced in the latter part of June will accomplish five or six moults before the cold weather comes. Even in the case of the adult — exceptional as it is among the crustacea — I think it probable that the shell is cast more than once in the year. The professional oysterman having taken up his best crop with the tongs, secures the gleaning with heavy iron dredges; and when using this instrument will take up an occasional Horse Foot, even in the winter season. In the unusually fine weather of an open February several years ago, in Rariton Bay, an adult female was in this manner taken out of the mud by the deep sinking dredge, when lo, the animal had but recently "shed," and its shell was still quite soft.

Sometimes the shedding can be witnessed under very unusual circumstances. A large female taken in August, although kept for many days in the open air, yet moulted in captivity. The operation was a very trying one, and required three or four days, as the animal got very dry. A little water was occasionally thrown on it for pity's sake; and even this was not marine water. Of course moulting under such extraordinary circumstances was a very difficult, and probably painful operation; the wonder was that it could be done at all. With natural surroundings a few minutes generally suffice for the task. A thin narrow rim runs round the under side of the anterior portion of the cephalic shield. This is in fact the widest part of the animal. Just before the time for exuviating a separation occurs

between this rim, and the perimeter of the anterior shield. To the unaided eye this rent is altogether imperceptible, but opens on the exertions of the animal; and at this opening it emerges from the old shell. Now as the opening is at the front, and in the place of the greatest width, and moreover as the shell is sub-coriaceous, and somewhat yielding, and at this particular place is very thin, it may be seen how great advantage the animal has in this matter over the higher crustaceans whose moult, from necessity, takes place from behind, and whose shell is composed of a more unyielding material. In the exuviation of Limulus I fancy a close likeness to that of the insects when leaving the pupa. The King Crab emerges at the forward, but under side of the cephalic covering; the beetle at the forward, but dorsal side of the same. It is plain that Limulus has an easier time in getting off his old coat than his "more respectable relations" have. To see the King Crab, as it were, coming out of himself, is a sight so odd as to draw from those beholding it the exclamation "it is spewing itself out of its mouth."

When the animal, specially noticed above, had come out of its old shell it was nine and a half inches in the shorter diameter of the cephalic shield; while the vacated shell was but eight inches by the same measurement. If they moult more than once in the year this would make their growth quite rapid; and if they do not, it seems to me that they must attain an age of not less than eight years before reaching the size that indicates adult life. But we must speak of this farther on. I have observed that every spring, that is, so soon as the water has lost its winter temperature, large numbers of the young of the previous summer are found in the shallows. These range from an inch to two and a half inches in the shorter diameter. As the creature when beginning life for itself, is but a scant quarter of an inch in diameter, this would imply rapid growth, and I think that the larger of the above have probably lived through two winters.

There are reasons for believing that the spawn is deposited

by the same individual more than once in the same season. I have heard this asserted with confidence by some fishermen. But as they could advance no proof no attention was given it until the following fact occurred. Let me first state that it is a custom prevailing wherever the Horse Foot Crab abounds, to catch it to feed poultry, under the belief that it makes them lay, as it surely does fatten both them and hogs, but imparts a shocking flavor to the flesh of both. The female is always preferred on account of its eggs, of which it has not less than half a pint, crowded within the cephalic shield. These are obtained by inserting the point of a knife into the forward, and under edge of the shield, and running the knife round through the thin rim, already described, when the entire lower part can be torn from the upper part of the shield, thus exposing the eggs, which are like mustard seed, but of an ashy green hue. Now a female that I knew to have spawned in May was in this manner opened in July, and was then to my surprise full of eggs, well formed, and with every appearance of maturity.

The Horse Foot Crab spawns at or near the new and full moon, in the months of May, June and July. By this, however, is only meant that they embrace the time of the extra high tides, which depend so greatly on the lunar influence. But mark the nice calculation herein displayed. They come up at a great high tide, advancing on the bottom, until they reach a suitable spot near to, but within the extreme line of this great tide. Three definite advantages are in this way secured. First, the spawning is performed under water, or without undue exposure; second, the line of the average high tide is thus selected; and third, a short exposure to the daily low tides is thus secured, by which the proper exposure of the spawning spot to the development-accelerating heat of the direct rays of the sun is obtained.

A visit of the adult Limulus to the shore line, except at the spawning season, is a very rare event. At this season they come up in great numbers in pairs; and it may be said

with no figure of speech, in true nuptial bands,—the male riding on the shield of the female, and retaining himself firmly in this position by holding to the sides of the posterior carapace, with the two stout and short nipper feet, which are exclusively possessed by the males, which with the size of the animal, so much smaller than the female, serve to distinguish the sex at a glance. The female excavates a depression in the sand, drops her spawn into it, upon which the male emits the fecundating fluid, and the nest is at once deserted, the parents returning seaward, with the retreating tide. Occasionally, a pair less alert than the rest, is left by the tide, which, however, they will overtake, if unmolested. By the action of the water the eggs are immediately covered up with sand; though if the wind be unpropitious, large numbers are often washed up, and cast in windrows on the beach, and soon devoured by the many hungry beings, of bird, fish, and mollusc kind that always abound.

Our Limulus is a true monogamist. But it is likely that a new mate is accepted each spawning time. Occasionally a female comes to shore with even three suitors attached, two of them vainly endeavoring to unseat the accepted one. The above has led to the belief among fishermen of a disproportion of the sexes. I think that this point cannot in that way be inferred.

Though formerly the Horse Foot Crab was very plentiful in Rariton Bay it has become rather scarce. Accordingly they have to be watched for now. Not having the time to spare I engaged a fisherman to keep a lookout in the month of May, 1869, for an actual spawning. He was instructed to see the pair come up and spawn, and to capture them at once on their attempt to return with the tide; he was also told to scoop up with a tin vessel the whole spawn-mass, sand and all, and not to touch the eggs with his hands. I believe the man faithfully obeyed instructions. Thus the spawn and the parents were brought to me uninjured. My preparations had been carefully made. Hatching jars had

been set for a number of days, and the water was in a fine state of oxygenation. One difficulty I had to submit to, of a serious character. I could only subject the water to the reflected light of the sun. The direct light would in the summer season prove too warm, and spoil my water. The result, as will appear, was that the hatching was accomplished very slowly, a fact which with another should be borne in mind while reading the following, namely, the absence of those conditions of agitation, variation of water depth, and sometimes complete exposure to air and sunlight, consequent on the tidal flow.

May 26, 1869.—To-day my Limulus eggs were set for hatching. Yesterday was full moon. The eggs were of a greenish white, dull, and rather dirty looking. My notes record no measurement, which I now regret. As incubation progressed the external shell became rapidly darker, and more coriaceous. But for this last fact I had become afraid that they were in process of decay. Several ineffectual efforts were made to get at the internal changes, but owing to imperfect instruments I gave up in despair, and determined to watch and wait for more advanced developments. There is considerable vitality in the King Crab's eggs. It will bear a good deal of retardation, and yet come out at last. It will be understood that necessarily my arrangements had a good deal of retarding effect. At the real amount I was quite surprised. Those on the surface progressed most rapidly.

July 18th.—Thirty-four days after spawning. The opaque chorion has cracked (Pl. 3, Fig. 1) disclosing the white pellucid spherical membrane within. Now a sight met me which gladdened my eyes. It was a living trilobite form. But of course very diminutive. Yet it could be seen with the unaided eye, and quite satisfactorily with a common lens. It is shown greatly magnified (Pl. 3, Fig. 2) in outline. Here the elongate character of the abdominal posterior is noticeable; also the excessive relative width of the thorax.

The figure shows only the upper side, but it has the feet quite advanced, and the two great eyes have well begun. In two or three days it was considerably changed (Pl. 3, Fig. 3). Though not so much, still the cephalo-thorax was relatively greatly in excess of the abdominal shield. The limbs, though not shown in the cut, were quite long, reaching beyond the edges of the carapace. The two sessile eyes were now prominent, but the central oculiform tubercles, as they have been called, but which I prefer to call ocelli, were wanting; for in their place, that is, the central anterior of the cephalic shield, was still a depression, or cleft, yet to be filled up in the progress of development. To me it seems that so far the development was markedly asaphoidal; that is, it reminds me of Asaphus, using that term as the typical genus of the Trilobites. Before passing, it should be observed that the embryo had its two segments inflected; and with short intervals of rest (not many minutes at a time) kept up a very active revolving within its pellucid prison; the effect of this friction on the walls of the hollow sphere would be to bisect it. As the embryo revolves it lies upon its back.

August 3d.—Seventy days from the spawning. To-day an embryo has left the ovum. It measures two and a half lines in length and two lines in width. Except for a little space in front the cephalic shield is armed on its perimeter by a series of briar-like spines, in two rows of about twenty-five each, the spines alternating with some regularity as to size. The curved rim of the pygidium, or caudal shield, is also fringed, but with setaceous tufts, each tuft being made up of hairs of different lengths. This new-born creature is in outline almost circular. The cleft in front of the cephalic shield has disappeared. The sessile eyes are now prominent, and are well up on the shield, the two ocelli are quite distinctly marked. But as yet there is nothing of the articulated tail that marks the parent Limulus, or its congener Eurypterus.

Such was the form (Pl. 3, Fig. 4) of the little being be-

fore me. Was it not a veritable trilobite? It at once began to shift for itself, making a persistent effort to burrow like its parent. By consulting the figure it will be seen that besides its tail-less aspect every feature is that of a trilobite. The abdominal, or caudal, carapace is relatively much wider than in the adult Limulus. The segmentary lines afford a very distinct trilobed character to both shields. The spiny and setaceous fringe finds its counterpart in many of the trilobites. The pointed tendency of the keel on the caudal shield seems to me to look towards Pterygotus. But if we take into view the presence of the ocelli already, and the high-up position of the large sessile eyes, we have Eurypterus shadowed forth. Let the reader examine Pl. 3, figs. 5, 6, 7, 8, 9, 10, which give an outline of the telson-plate, or terminal tail-joint of as many separate species of the fossil crustacean *Pterygotus*. Fig. 5 is *P. Banksii*, in which the telson is marked by a cleft. Fig. 6 is *P. bilobus*, showing the cleft less marked, and the presence of a median ridge or keel. Fig. 7 is *P. gigas*, in which the keel is more developed, showing a higher relief, and a greater prolongation, and the disappearance of the cleft. Fig. 8 is *P. Ludensis*. Here the keel is still more acuminated, and the plate itself is mucronated. Fig. 9 is *P. bilobus*, its size being very much reduced. Fig. 10 is *P. acuminatus*. Here the keel has attained an extreme length, and great relief, and is with the plate carried to a slender point. And this prolongation of the telson plate into a terminal spine, is, I think, in respect of posterior development, the highest effort of the Pterygotus. I also think that this is shadowed forth in the embryology of Limulus. But it should be noticed that there is not so far, in all this spinal tendency, anything in the direction of an articulated spine. That is, there is nothing xiphosuroid, or sword-tailed in all this, as in Limulus, and the fossil crustacean Eurypterus, which have an articulated bayonet-shaped appendage. Now Pterygotus has two sessile eyes, and only two, and these are placed low down on the very edges of the

forward shield. But Limulus and Eurypterus have both two large sessile eyes set high up on the shield, and two ocelli set forward.

The want of an articulated tail was soon apparent in the case of our little Limulus. The slightest obstacle turns it on its back, when, not having this organ, which the adult uses so effectively in such emergency, the little thing begins a vigorous flapping of the branchial plates. This causes it to rise in the water; then by ceasing the agitation it at once descends, with a chance of alighting right side up. Should it miss the ascent would be repeated until its desire was accomplished.

August 15th.—Eighty-two days from the spawning. A great many had hatched, and many had perished for want of care. I had almost given exclusive attention to the one described above. It had its second moult to-day. A few minutes sufficed for it to withdraw itself from its baby suit. I noticed that it stopped a little while, as if to rest, having the caudal appendage only half withdrawn from the old shell (Pl. 3, Fig. 11). At last out it came, a person of distinction possessing the articulated rapier. It is a true Limulus now, and fully entitled to carry for life, the sword of honor, which has ever been the family mark of rank. The animal is now quite a fourth of an inch in width, and its tail is the one-twentieth of an inch in length. Where did it keep it while in the old dress? It must have been bent under and upon the abdomen. I have noticed them since at this moult, with the tail considerably incurved, and which required some hours to straighten out. Dorsally the little thing has now nearly the complete appearance of the adult Limulus. The setaceous fringe of the abdominal carapace had disappeared, and had left an armature of teat-like or half-developed spines; and the spiny fringe of the cephalic shield was quite gone. The posterior projections of this shield are now sharp. The tail is distinctly articulated, but somewhat stumpy. A section of the adult tail would be al-

most triangular, the lower side being slightly rounded, the upper sharply edged, while a section of the tail of this young specimen would be almost ovoidal. The tail of the young is also more distinctly marked with lines of segmentation than is that of the adult. As it travelled on the mud before this moult, it made tiny rows of toe-tracks, leaving a plain unmarked space between the rows. Now it moves with tail depressed, and makes a medial line dividing the toe-tracks into two series.

Alas, at this point, when I had become intensely interested, a serious illness, against which I had offered a dogged determination to keep at work, peremptorily settled the matter by taking from me the use of my eyes.

It will be noticed thus far that the observations here recorded, are almost entirely morphological, and not physiological. Professor E. D. Cope has given us a lucid phrase, "expression point." He says of development, "while the change is really progressing, the external features remain unchanged at other than those points, which may be called *expression points*." It seems to me that "expression points" of generic significance have been pointed out four times in these remarks. Twice in the ovum I thought there was an "expression point" of a trilobed genus; and in the larval stage, I thought Pterygotus and Eurypterus were shadowed forth.

And in the metamorphoses of the larval state there are remarkable changes with reference to functional necessities. Already mention has been made of the moult at which the animal receives its articulated tail. Now in the life of Limulus this tail is as indispensable as is the Alpine stock to the Swiss mountaineer. It is constantly liable by the least agitation, or obstruction, to be turned on its back, when but for its tail it would be as helpless as a tortoise in the same position. It is then that it deflects the tail, and inserts this sharp spine into the mud or sand, and after a few persevering efforts succeeds in turning itself over. So feeble are

its limbs that exposure of the under side to the attacks of fishes would soon end its career. In short it must keep its carapace "right side up with care," if it would care to live.

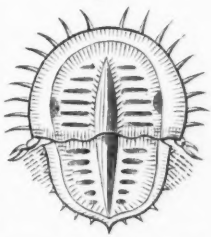
I must now mention another functional metamorphosis which seems to me of a very remarkable character. So great is the difference in form between the anterior feet of the female, and the same feet in the male, that the very children on the shore lines at once in this way distinguish the sexes. In the female this limb is long, slender, and weak; in the male short, stout and ventricose. Intended for strong holding, their nip is like that of a vice. Their use is to hold on to the carapace of the female, so that the male may retain his position as the pair come up in the breeding season. And so strong his hold that no violence of storm, or attack of rival suitors, can displace him. Well does the fisherman know this, as he stands in the water ready to spear the female as she comes up in nuptial embrace. He is only concerned to catch the female, for it would need some force to separate the two. Now functionally, this stout foot, "or hand," as the fishermen call it, has no use in early life. The Horse Foot Crab has its period of puberty; this is its adult stage. But judging from the size of the males when they couple, which is pretty uniform, and their actual rate of growth, I think that the puberty of Limulus cannot come before the third or fourth year. And it would not surprise me if the latter figure should prove the minimum age. However this is the point—it is not until that age of puberty is reached that the male undergoes its last metamorphosis. It then has a moult, from which it emerges, having received its large claws, or, literally, its nuptial hands. What change there may be on the emotional side who can tell, when master Limulus assumes the *toga virilis* and is old enough to "propose." This may be asserted of these very decorous and monogamous people, that among them premature marriages are unknown, for however soon the lady may be ready to give her heart, not until maturity of age can the gentleman possibly extend to her his hand.

The above fact was obtained by evidence purely negative, yet not the less convincing. First, there was the suspicion of the fact, then the search for a young male possessing nuptial claws. But albeit the numerical equality of the sexes this was not found, though large numbers of young specimens of different ages were examined. Moreover, I have not found the fisherman who has ever seen one.

Although some of the systematists make of Limulus a distinct order, as *Xiphosura*, or sword-tailed; yet I cannot but think that in nature the Trilobites are included, making of all one grand order. It would thus have not only a real systematic meaning, but a profound chronologic significance. However this may be in the light of coming knowledge, I think Pterygotus and Eurypterus stand higher than the typical Trilobite proper, and that Limulus leads rank over all.

Figure 68 shows Limulus after the first moult (very much enlarged), when not more than a week old. The fringe of the buckler is now less thickly set, the cardinal spines only being conserved, and these not so stout. The posterior shield shows the permanent spines. Still the contour is asaphoidal while the median ridge of the abdominal carapace, terminating in the point of the mucronated shield, is suggestive of the dorsal keel in *Pterygotus gigas* and *P. anglicus*. At this stage, as the facts seem to me, the larval Limulus shows forth more than one generic "expression point" in the career of the trilobite as a "comprehensive type."

Fig. 68



Limulus after the first moult.

It should be stated here that the exuvia represented by fig. 68 was accidentally discovered on the surface of the mud, at the bottom of an hatching jar, used in these observations last summer. At the close of the warm season last year my jars must have contained not less than two hundred young Limuli. We have already said that so soon as

hatched the young burrow like the adult; hence the rareness of an opportunity to witness the casting of the skin. Hoping to continue observations upon the growth of my interesting family the ensuing year the jars were carefully put away. Little regard, however, was paid to temperature, which, on several occasions, went down to the freezing point. On the 3d of May, 1870, I emptied the jars to see how my charge was getting on, when lo, not one of the last year's hatching was alive! but wonderful to say at least a dozen little fellows, all hatched this spring, and all alive, had taken their place. With these were also at least thirty eggs, in different, but all in advanced, stages of incubation. In some of them the young could be plainly seen revolving. The fact was these eggs had been at the bottom of the hatching jar, and had never had any contact with the sunlight. At once, not without some misgiving as to the result, the proper provision was made to complete the incubation, namely, new sea-water, clean sand, the eggs put on top, and all set in a favorable place. With an ordinary hand lens the progress of incubation could be observed daily. At half-past four o'clock on the afternoon of May 11th, before my eyes, a new-born baby Limulus left the egg. Just think of it—these eggs are within two weeks only of being a year old! And then how remarkable are these facts also—those eggs were partly incubated last summer. Hence there has been not only a remarkable retardation of development, but also an actual arrest of the same for seven or eight months without sacrificing life. Query: is there any connection here with that indomitable persistence of being, which in the Divine will has carried this comprehensive type through the many EONS of existence, wherein has been unrolled so slowly the life plan of the Entomostraca, from that initial Trilobite of the Pre-siluria to our Limulus of these latter days?

It has been hinted already in this article that at different stages of its life the larval Limulus made a different impress

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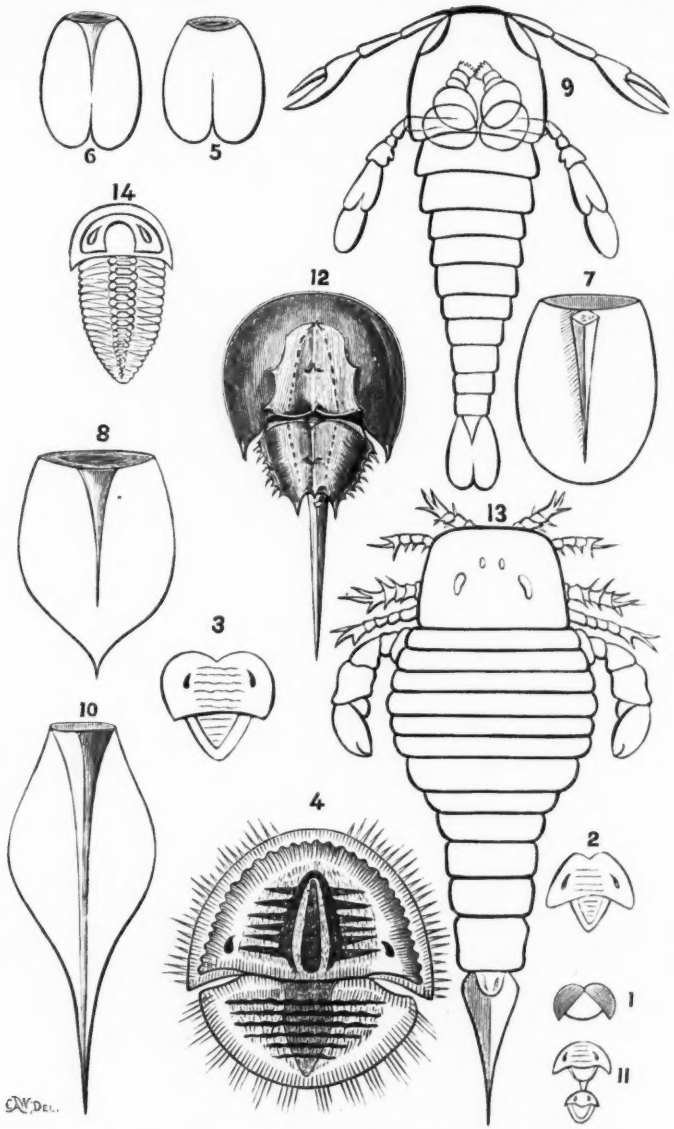
JOHN CREHAN



LOCKWOOD ON THE HORSE-FOOT CRAB.

when it walked. While tailless there were simply two parallel sets or rows of toe-tracks, but when tailed those parallel rows were separated by a median line, showing the caudal trail. Is there not here a caution for the interpreters of the "Protichnites" seeing that the same species, at diverse ages, may make widely different tracks?

Not more than three or four exuviæ were found entire in the mud of the hatching jars. In all the rest the buckler and the pygidium were separate. Now it is not the case that the Horse Foot shells, in the long wind-rows on the shore-line, are entire. The entire ones are decidedly exceptional. Before certain tides the young are helpless; but the adult never comes shoreward except to spawn. Hence their exuviæ are brought up by the wash and the under-tow of storms, thus effecting the separation of the two parts. Is there not here an explanation of the great abundance of the pygidia, or caudal shields, of the *Asaphus Iowensis* in the Iowa limestone rocks? I do not regard them as the debris of dead trilobites but as their cast-off shells. They are the tidal windrows of that ancient sea. The articulation of the two carapaces was no doubt feeble; and the specific gravity of the pygidium less than that of the buckler. In this case the debris would be sorted into different depths of water. The bucklers would be less crowded, because in greater depths where the tidal action was less; while the lighter pygidia would, by the same law, form the drift of the shore-lines.

EXPLANATION OF PLATE 3.

Fig. 1. Egg of Limulus just cracked by incubation, showing the pellucid sphere.
Fig. 2. Embryo in the egg, much enlarged.
Fig. 3. Same two days older, much enlarged.
Fig. 4. Young Limulus just out of the egg, enlarged nine diameters.
Fig. 5. Terminal tail joint of *Pterygotus Banksii*.
Fig. 6. Terminal tail joint of *Pterygotus bilobus*.
Fig. 7. Terminal tail joint of *Pterygotus gigas*.
Fig. 8. Terminal tail joint of *Pterygotus ludensis*.

Fig. 9. *Pterygotus bilobus.*
Fig. 10. Terminal tail joint of *Pterygotus acuminatus.*
Fig. 11. The smaller one is Limulus just hatched, natural size, mere outline; the larger is the same undergoing the first moult, and leaving the old shell, and having a tail.
Fig. 12. Limulus Polyphemus, one year old. The markings on the posterior carapace become less distinct with adult age. The adult female will attain a size even exceeding twelve inches across the cephalic shield.
Fig. 13. *Eurypterus remipes;* size very much reduced.
Fig. 14. *Sao hirsutus,* a trilobite.

THE SEA-WEEDS AT HOME AND ABROAD.

BY JOHN L. RUSSELL.

THE vegetable productions of the ocean, like those of the drier portions of the earth, are subject to a similar order of distribution. The most common collector of plants becomes soon aware that there are kinds which are not to be looked for in ordinary places, and soon learns to set a value on those which rarely occur to him. He also desires to extend the area of his observations so as to embrace different latitudes, or to obtain the same results by ascending lofty mountain heights. So the collector of sea-weeds does not confine himself to particular districts, but endeavors, either by personal inspection or else through the labor and courtesy of others, to ascertain what forms, seemingly familiar or entirely diverse, may grow abroad. The deeper soundings of the ocean-beds, like the higher elevations of the land, afford him a greater variety, affected by different causes, which in their natural course produce different results.

The general plan of vegetable life, especially in the lower plants, seems to point to constant modification of some one typical form, and this modification appears to have its origin in climatic influences. It becomes a most fascinating study to endeavor to join the separate and divided links so as to

possess, in a series of specimens, the probable method of development which nature has thus instituted. Let me endeavor to adapt this idea to the thoughts of this present essay, and arrange to some extent the sea-weeds (*Algæ*) of our own and of foreign or distant coasts together. Let us see in what kinds there are corresponding ones; and when we select some choice specimen from the beach-drift, or pluck it from the rocks, endeavor to tell on what distant strand it is obedient to the pulsing waves, or perchance attracts other eyes.

The coast of New England presents as great a diversity in outline and in character as perhaps can be found in the same length of the Atlantic shore. We have here the deep inlets like Norwegian fiords in Maine; the bold rocky promontories of Massachusetts varied with the almost level and smooth sands of the South. The noblest in size, as well as most beautiful in color and features, are the algæ which are to be met with throughout this wide range. The would-be successful collector must resort to the dredging apparatus, and like the shell collector needs a strong arm and abundance of patient toil to serve him; else he must wait some violent storm, which shall break from their deeper moorings those more valuable weeds which only can grow perfectly and develop themselves entirely far below the surface, where the sun's rays but feebly penetrate and the water is of a nearly uniform temperature. Some wonderful waifs are occasionally met with in this way by visiting the beaches and picking over the waste with scrupulous care. In the warmer waters of the Southern States, like those on the Florida Keys, there may be sought singular kinds resembling corals, for which they were formerly mistaken by Lamouroux, some of exquisite beauty in design and shape. Some of these are found growing from the base of a Gorgonia or sea-fan, and secreting from the ocean their covering of lime. And others of richest green creep over the sand beneath the water, and throw up a turf as verdant as that which clothes

the most luxuriant pastures. This field of botanical enquiry is yet open, and many a desirable harvest can be reaped, from season to season, out of the treasures of the deep, and the yet undiscovered or little known species of New England attract the deserved attention of the casual visitor or of the sedulous student.

Let then the season be summer, the warm days of June, when many people as naturally resort to the seaside as if the custom were instinctive and migratory. To some the scenery is the same and familiar, and the cool air is the main thing to be realized; to others, though familiar yet ever new, and to others every object, however minute, is novel: The very rocks and cliffs are different in looks, composition and general features; the sand composed of curious minerals, tiny shells and comminuted fragments; the wild flowers wierd and unusual; the thick leaved and prickly seeded plants thriving within the spray's reach; the beach cumbered with productions of the sea — mineral, animal, vegetable — thrown in wild confusion. Who, for the first time, is not moved with wonder at these sea-weeds? Who would not wish to become better acquainted? And no wonder so many are gathered, floated out into shape, dried, pressed and carefully laid away, silent witnesses that beauty and utility are often combined where little dreamed of. The interest increases with each coming season; the practised eye soon learns to discriminate; the cultivated taste finds the most propitious time of the year for collecting, and such trifles, employed at first to while away an hour or two, are often found indispensable and auxiliary to the very enjoyment of life.

Suppose we start on a walk for some gravelly beach contiguous to some town or city, and removed from it by the interventions of wild pastures, rocky and almost desolate, or by some level, wide extended marsh. At any season of the year, when walking is practicable, the botanist who accompanies you, can point out abundant objects of interest long before you come within sea range. The intervening

space proves not so dreary or desolate as it appears, for often our most interesting and best friends have the rudest exterior. Perhaps he knows something about the lichens, those dull green, grayish, yellow, bright orange, black crusts, scales, fringes, torn, ragged felts; or perchance those dry, crisp, brittle, crimson tipped, blunt tipped, sharp pointed, branching anomalies which cover many an acre of sterility where nothing else grows, and where the surfaces of rocks and the rough bark of trees cannot offer them any chance. He will be able to introduce you through these desiccated and seemingly lifeless plants, the lineal descendants of the first forms of vegetation which appeared on the dry and solid earth, to the wonderful and more grotesque, more developed, sometimes enormous sea-weeds which, at the birth of Creation, sprung into activity as plants in the "waters which covered the face of the deep." Nay, you need not heed these unless you choose, although within every one of them lies enfolded a wondrous tale, locking up in the recesses of their natures, health and healing and joy. Notice too as you walk, the fair flowers springing up on every side. If autumn, or early winter, a bright October's day or a green Christmas, you may yet find for your admiration such seed-vessels, such starry calyces, such feathered down, such inimitable trifles as no gold could purchase or art fabricate.

Such rough and confused pasture lands lie between Rockport and the sea; between Gloucester, between Marblehead, Cohasset, Scituate and many famous places, and the beating ocean. By the very marge of one such beach I have found plants seen nowhere else by me except on mountain sides. Think of Rockport in July, lovely in the masses of mountain laurel, and this fine native shrub opening its clusters of flowers within sight of the very sea. From the land side the very odors of Araby the Blest come over the Manchester and Gloucester waters from the magnolia, and gladdens the heart of the returning fisherman. The very rocks, worn smooth by the surf and rounded and polished, extend

just so far inland, which the closely attached lichen defines by its persistence in bright yellow colors in the strict line of terrestrial and maritime growth. They stand there patient sentinels to denote that the floods shall no more cover the earth; the lichen the earth's plant, and the alga the sea's plant, approximate and almost kiss each other in approach. Nothing higher in the scale of organization ventures so near; not the sedge, bulrush or hardiest grass dare grow so close to the waves. Nor are lichen and alga far removed in consanguinity; in structural difference something; some more exposure to sun and rain, to snow and ice, to heat and cold, in existence and continued individual life vastly more in favor of the little crusted slow-growing lichen, patient, untiring, serenely beautiful, doing by day and night its usual work and breaking down the hardest and most obdurate rock formations by the gentlest persuasion of its constant presence to aid the atmospheric influences.

The algæ are so diverse in their forms, and so many in number, computing only the precise kinds or species, to say nothing of innumerable varieties, many of which have been separately and minutely described, that in order to facilitate the labor of finding out what they are it has been found best to divide them into three great groups known by the color of their seed-vessels. But as it is not always possible to find their seed-vessels, or even those minuter parts which though not seeds serve for similar purposes, because like other plants, and what we call flowers or flowering plants, these too have particular seasons of the year when they produce them, so to look for strawberries after the vines have done bearing would be precisely like looking for seed-vessels on sea-weeds when they had passed the season. Some kinds, too, like some other and higher plants never bear any seeds in our latitudes, but such seed bearing plants must be sought elsewhere. Fortunately in this dilemma the chances of success are in our favor, and the usual color of the sea-weed corresponds with the color of the seed it bears. The rosy or

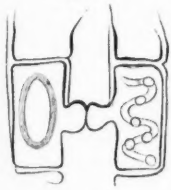
red-seeded algæ are usually the most popular because the prettiest; but others, even the black or fuscous-seeded algæ have many claims on our attention. I will venture, however, to set both these kinds aside for awhile, and speak first of the green-seeded algæ, the *Chlorospermæ*, as they are called in the books.

In the rear of some beaches, like that known to the old folks about Marblehead, as Devereux's beach, perhaps it has now another name, surely none more euphonious — may be seen large extended reaches of salt or brackish water, covered with floating masses of a light-green tangled fibre, and which lies in flakes upon the tips of the growing grass, or cast ashore to desiccate and fade in the bright sunshine. Lifting carefully a little on the end of a sharply-pointed stick we shall find a great many silky, glossy threads, each slender, sparingly branched with alternate and scattered branchlets somewhat spread apart; sometimes growing on one side, each joint several times longer than broad. Within each joint look after a green granular mass which answers for seeds, and to do this you must have a pocket lens for your eye; at home a compound microscope would do better, and in this rapidly growing and widely extending Chlorosperm you have taken your first lesson, perhaps, in studying the algæ, having been introduced to the *Conferva flavescens*, and if possessed with farther curiosity you may learn of other Confervas of equal or surpassing evidence. The extreme lightness which these sheets of dead fibres have, renders them easily elevated into the higher strata of the air, whence they have been known to fall in violent showers far into the interior, spreading consternation by their presence in such an unusual manner, and greatly frightening the superstitious and ignorant. Sometimes this substance has been called "meteoric paper," and I have seen in the microscopical cabinets of my acquaintances fragments of similar matter from very remote parts of the globe. This single species has been observed extensively in Europe and

America; and the few students of our native kinds have been rewarded by meeting with several others, identical with species which grew on the other side of the Atlantic Ocean, such as *C. bombycina*, *rivularis*, *aerea*, *refracta*, etc. But perhaps the most curious of these water silks, as they may be termed, credited to the northern lakes and to those lovely sheets of fresh-water in Central New York, is the *C. glomerata* of the earlier writers, but now called Cladophora, on account of the peculiar manner in which the joints arrange themselves, being either packed together in strata or layers, or flexed and curved in long and delicate lines; and another, far more curious, of which there are many sorts distributed from Sweden in the far north, to Cayenne in South America; found in Cuba, in New Zealand, in the lakes of Germany and in the fresh-waters of Great Britain; and worth looking after here, is the *C. ægagopila*, its filaments rolled together like a compact ball, and when dry, sometimes used for pen-wipers. I have looked for it, but always in vain; other delicate and pellucid-jointed water plants sometimes do so, but evidently they are only imitations. In the ditches and by the sides of shaded paths where the water is stagnant, similar Chlorosperms may be seen. Is there any identity and do the same algæ grow indifferently in fresh and salt water alike? The question is worth attention, so let us when we retrace our steps examine. Here I have lifted on the end of my cane some of these floating, swollen masses; they also are fibrous and silken, but see! how different is the green coloring particles within the joints! Here are a few in which the seeds are so arranged that the joints which are only about as long as they are broad, and vary in length, are marked by two roundish stars. It is but a rude idea produced by the arrangement of the seeds, but as these stand side by side in the parallel joints of two of the silken filaments of the tangle we have lifted from the ditch, and which are joined laterally by a connection or bridge, they remind us of the mythological story of Castor and

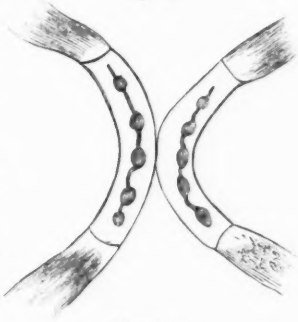
Pollux, the twins of Tyndarus, and our humble alga is accordingly called *Tyndaridea*, and of it are many kinds growing tangled even, in the same mass. In similar and equally unlikely places for beauty to dwell and abide we can gather the *Zygnema*, or Yoke-thread, in the joints of which the green granules are at first arranged in spiral rings, but afterwards collect into a single globule as the future seed (fig. 69). In one species the spiral lines become a series of the Roman V, and in another of the letter X. Strangely, too, do the delicate and fragile filaments or silken threads bend at acute angles, the coloring matter first filling each joint, but soon contracting into a narrow continuous stripe. In this and others of similar behavior and appearance we have *Mougeotia* (fig. 70), named in memory of a botanist, and bearing his surname. They are common in Europe and New England. Before we leave these rich green, emerald and vivid, or pleasing green weeds of the stagnant and brackish pools, let me tell you of a pleasant surprise I once had in the sunny waters of an overflowed and stagnant pool formed by the rising of the lake, and there permanent through the year for want of means of draining it. Years have fled and the pool is solid ground now, covered by the property of the railroad company, and near Burlington, Vermont. The conchologist may be pleased to learn that *Lymnæa megasoma* Say, once lived there; but my finding the elegant water-net, or *Hydrodictyon utriculatum*, previous to its being seen by the celebrated Bailey in Philadelphia and at West Point, will always

Fig 69.



Zygnema.

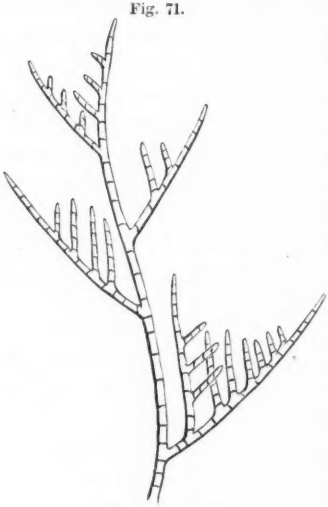
Fig. 70.



Mougeotia.

connect a delightful remembrance with stagnant pools and still waters in my mind. In this pretty aquatic the joints are united at their ends into regular pentagonal or hexagonal meshes, and form a tubular net which floats in the water. Turning again towards the sea let us look into these salt pools among the cliffs, some shallow and others deep and lined with exquisitely colored algæ too. Certainly, so far as looks go, some of these verdant and glossy silks should be Confervæ, but having been instructed better by the lens let us see what it will do for us here. This flossy silk, how delicately and gracefully it floats just under the surface, but a little of it lifted into the air collapses in a very ungrateful way. Yes! you have gone out of the realm of the Confervæ and only resemblances occur. Thus your floss silk, so entangling, inelegant in the air, shows its elegant proportions and finer divisions in its native elements and in water of a denser medium. It is a tuft of a true maritime Chlorosperm (fig. 71), one of a very large genus, and as Professor Harvey tells us, difficult to define; so we must be content with our present knowledge to observe and admire. Some tufts of darker green colored and bristle-like jointed filaments stand stiffly in the water; they are worth gathering, and bear the name of *Chætomorpha*, or Bristle alga; the most common with us is the *Melagonium*, but several others may be found on the New England shores and the Mediterranean, the Canary Isles, Algiers, New Holland, Tropical America and the East

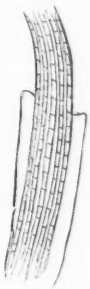
Fig. 71.



Chætomorpha.

Indies; the northern and southern portions of the globe delight in their presence. For specimens they only dry indifferently, the joints shrinking by dryness, but the algologist cares little for looks. Very marvels are those closely adherent algæ, which creep over moistened surfaces, and some of which are found on rocks wetted by the sea, many in springs of flowing water, some in hot springs, and such unlikely places; but I should scarcely forgive myself if I overlooked in this connection the *Microleus repens* (fig. 72), in masses resembling a green slime of almost black intensity; but lifted from the wet path and a few of its conferva-like threads magnified, shows its claim to regard. As the little bit expands under water the microscope assists you to see the oscillating motions of its jointed filaments, creeping apart from each other like the measured progress of the hand over the dial plate of your watch!

Fig. 72.



Microleus repens.

Similar, but not tied up in little sheathing bundles, are the pretty *Lyngbyas*, snarls of silky fibres, but each in a mucous sheath by itself and divided into numerous transverse joints of rich deep green, purple, brown and other colors; widely diffused over the globe and extensively scattered over wet surfaces, faces of rocks, and places where we should expect nothing curious or striking. They too, boast of many kinds of residence in the sea, in salt marshes, among pebbles on the shore, in hot springs, and the water of salt works, living alike in fresh or saline homes.

Some few larger and more specious Chlorosperms are those rich green crisped and wavy-margined thin algæ, which lie upon the soft mud after retreating tides, covering unsightliness with continuous beauty, and refreshing the eyes. They are known as "lavers," *Ulvæ*, and two or three species are well known. They do not make very pretty specimens, but pieces of them can be advantageously employed in arranging

other kinds. Sometimes they are served up with lemon juice under the name of Oystergreen, and as a diet are considered of good repute. The broadest leafed kind are selected. The green particles which correspond to the seeds are deeply embedded in the pulp of the entire plant, and commonly arranged in fours, while those of the Purple laver (*Porphyra*), which notwithstanding their color, so distinct from the seeds of the Chlorosperms, form an exception to the general rule, and though possessing rounded granules, quaternally arranged, are also provided with clusters of oval seeds (fig. 73) besides thus indicating a step forward in the progressive development. To find this pretty alga it is well to examine the piles and timbers of wharves, and the perpendicular faces of rocks submerged by the tides. Other and finer species than our own have a wide dispersion, and in common with the green lavers may be frequently met with, abroad, in similar situations. Not very unlike their cousins, the Ulvæ, are the grotesque looking, pale green, inflated bullate Enteromorphas, tossed in wild confusion, and mingled irrespectively together, with the usual rejectamenta of the sea upon the rocks; despised and overlooked as they are apt to be there they are respectable Chlorosperms when growing and thriving under the water; and a little care and attention to their merits will give them their place among the dried trophies of the ocean gleanings. Singularly alike, and yet different, are the *Tetrasporas* of the fresh-water, floating quietly upon the stream, their lax netted tissues of pleasant green color having their interior substance dotted over with clusters of seeds arranged in fours; and others of humbler pretensions but of wondrous symmetry and beauty nestling like small disks upon the pebble or upon the submerged log, or throwing wide upon the current their elegant beaded filaments like necklaces of strung jewels, embraced by the Chlorosperms or claimed by aberrant forms of the Confervæ.

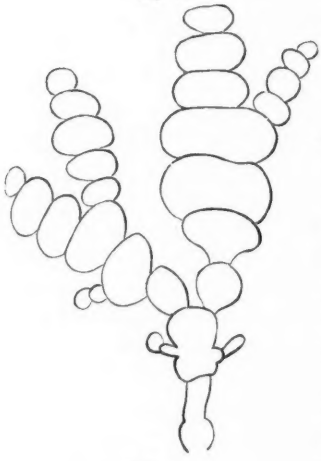
Fig. 73.

Seeds of Porphyra.

Some tropical sea-weeds belonging to this section now claim the attention. These are the Siphonaceæ, so-called because whatever be the form or size of the alga the different parts have a continuous cavity throughout like a pipe or siphon. And a very great difference exists in these several forms, some of which are very singular, others very beautiful. They are described as green, marine or fresh-water algæ, either naked or else coated with carbonate of lime, which they extract by the method of their growth and life from the water. A few kinds, of which the elegant *Bryopsis* is an instance, are found in our northern bays and waters. It is a pretty little green-tufted feather-like alga, parasitic on other weeds, and growing on the rocks near the shores. Yet in its range it reaches to Cape Horn, the Falkland Islands and New Zealand. The green particles within its substance break up into smaller parts, and bursting through the sides of the branches escape to furnish the needed seed dispersion. In a somewhat similar branching kind, but in which the single jointed filaments and branchlets or twigs, as we may call them, are compacted together into flattened bundles, so as to look like a rude fan furnished with a handle or stem, and the sticks somewhat encrusted with carbonate of lime, we have the *Udotea*, named by Lamouroux after some ocean goddess, known to Hesiod. One species, the *U. conglutinata*, of Lamouroux, has been seen growing at Key West; and another, in which the lime is uniformly and evenly deposited on the entire surface, much more resembles a spread-out fan, and is known in our tropical seas as *U. flabellata*, while other seas produce still other forms. They are so bizarre and unlike ordinary algæ that no one but an adept would recognize their place among sea-weeds. In *Halimeda* (fig. 74) we have still other singular and anomalous looking plants, short-jointed and broadly dilated for the length of the joints, looking not unlike some smaller truncated cactus of the green-house, but soon fading to a dull white tint, and on drying becoming brittle. Several species are met with

on the Florida shores, of which, perhaps the *H. opuntia* is the most common, as I have picked several fragments of its clustered stems from gorgonias and corals collected among the Keys. Removing the lime encrustations, a singular skeleton of fibres, branching off into clusters of smaller branches, presents itself and which serves as a support to the tissues. In company with these oddities is another singular marine production, composed of innumerable slender, single-celled branching filaments, inextricably woven together into the form of a hollow ball, and which grows from the size of a cherry to that of the human head, and is known in the European seas as *Codium bursa*, or Sea-purse; while another species with a narrow, long, branching form, but with fibres similarly entangled and woven, has been found on the coasts of California, but is not known on the Atlantic shores of New England, a prize perhaps for some sea-weed collector! Of the other siphon-constructed algæ may be cited the *Caulerpas*, elegant, green, creeping-rooted algæ, mimicking under graceful forms, the ferns, club-mosses, feathery mosses, ground pines, selagines and other higher cryptogamic plants, such as grow in the woods and in bogs remote from the sea; investing the submarine sands and tide-washed rocks with perennial verdure and loveliness, and found alike in every tropical sea on the globe.

Fig. 74.



Halimeda.

These lime-bearing algæ so far away from our personal observation, and to be seen only in our most southern latitudes, should have some representatives on our northern

shores, and it is to the Corallines and their allies that we will turn for farther enquiry. Leaving, however, unwillingly, the attractive Chlorosperms we will make some acquaintance with the beautiful family of the Rhodosperms, or rosy-seeded algæ, plants corresponding in the tints and colors of their external and internal arrangements, with the elegance of their seed-vessels and seeds. In outward habit the Corallines present also considerable variety from the simplest and lowest in the mode of increase similar to that of the crustaceous lichens, spreading in horizontal concentric circles, or gradually developing upwards and outwards in the form of stems and branches. On every part, encrusted in their lime covering which moulds itself to the joints, swellings, depressions, ridges, or into the flutings and channels of the surface, or surmounts the very tips in the form of seed-vessels, one would scarcely suppose that these elegant marine productions — so abundant in every tide pool, and fringing the deep cool grottos beneath the water-covered rocks, or lining with patches of pleasing and varied colors their sides, or laying down tessellated and mosaic pavements, by encrusted pebbles presenting to the vision variety springing from their secreted cements — were sea-weeds and marine vegetation. But an immersion in diluted mineral acids dispels the mystery; the usual tender and flaccid tissue of cells and pulp appear in due proportions beneath the covering which looks so much like the fabrications of the polyps, and in the absence of microscopical investigation these innocent plants were described and figured as animals related to the corals, and from their smaller size and comparative insignificance were called Corallines. Very rarely found in the colder seas the one species best known at the north is the *Corallina officinalis* (fig. 75), once in fictitious repute in medicine. You cannot miss it, growing as it does in the pools left by the tides, and to be picked from the beaches attached to some shell, most usually the larger muscle (*M. modiolus*), thus indicating its range even in

deeper soundings where that mollusk abounds. A much more slender and delicately jointed kind, scarcely more than simply branching, is the *Jania*, presenting under the surface of the ocean a violet green tint, which soon changes to a more or less deep rosy or red, and finally becoming shining white if exposed to the air and light, growing parasitically on other sea-weeds and widely distributed. Some elegant species are known in Cuba and on the southern coast of the United States, and others are found in the oceans about Australasia, Cape of Good Hope, etc. The *Amphiroæ*, also widely distributed over the globe, are lime-bearing Corallines, the joints cylindrical, separated from each other by bare portions of the horny axis, the seeds lodged like those of all the Corallines in conical wart-like conceptacles, the different parts of the little plant on which these occur furnishing some criterion to determine its real name. Beautiful and interesting as they seem in living condition, a more intimate examination assists in revealing their curious structures. Having in this excursion for northern lime-encrusted sea-weeds stepped into the domains of the Rhodosperms, or rosy-seeded algæ, let us take leave of our verdant acquaintances, and cultivate the friendship of a higher series of marine plants, whose seeds and seed-vessels are more curious, elegant and diverse.

Fig. 75.

Coralline.

The algæ in this order are by far the most universally attractive of any of our native kinds. That part which looks like their foliage, and is technically called the *frond*, is liable to a great difference in size, shape, and outline, in some being broad, or flat, or narrow, or thread-like, the main stem frequently dividing, or the disk-like support on which it rests suddenly spreading and ramifying upwards, the branches often arranged in regular pinnæ, or lateral wings,

and these again dividing into smaller branchlets; or the broad, thin, membranous leaf throwing out similar but smaller ones from its edges; the seed-vessels often displaying much beauty and elegance of design, and variously distributed in the leaves; add, too, that gathered at almost any season, they make pretty specimens for the album, either as portions of the plant or even as fragments, it were no wonder that equally with the child and the adult the Rhodosperms become favorites, and are considered foremost among the wonders of the sea.

Attracted by the brilliant crimson feathery bit which now comes riding on the crest of the wave, the attempt to secure it as a prize is successful. It came from deep soundings, and has been torn off from the friendly support of some gigantic kelp, by a sudden swell or rude wind. Thousands of just such bits, and some of them several inches long and broad, you can pick out of that drift high up on the beach. It is the *Ptilota serrata*, and though so common here, should you chance to gather algæ on the coast of California you will find it there, the denizen of the Atlantic and Pacific alike, while those who collect for amusement from the beaches of Rhode Island, New York, New Jersey, etc., may find another, *P. elegans*, likewise found at Beverly and its neighborhood, a smaller and softer plant with jointed pinnules. On the tips of the main branches, and enclosed by the curving of the smaller, are lodged the pretty conceptacles or seed caskets, giving the plants a feature of interest. The species of Ptilota are not numerous, but they are found in most parts of the world. A still more beautiful fragment is this which I have at this moment rescued; I find it frequently with the last but seldom can I find a perfect piece, such as is now lying on my study table at home, from the English coast. In outline and ramification a little like Ptilota, but its dichotomous branches are two-edged with a sort of thickened midrib, its color a dark lake, and it dries into good shape. It has two kinds of seeds, some growing

in the pulp of the frond in clusters (*tetraspores*), the others issuing from conceptacles which grow on the outside of the smaller branches. On the French coast it is called *P. vulgare*, or the Common Ptilota, and Kützing says that it occurs in the Atlantic, Pacific, and Southern Oceans.

The Carrigeen moss, so well known in the preparation of food, and to many more familiar on the table than on the shores of the ocean, is the *Chondrus crispus*, really an elegant alga. It is subject to many varieties, and the best way to study them is to go down as far as you can among the rocks at low tides and see the plant growing. A careful drying of some of the most prominent sorts will repay. Those gathered from the beaches are more or less bleached or discolored, and generally filled with sand. In similar situations, and even growing where the water is always deep, some other algæ similar yet distinct may be sought. Like others which grow out of reach except by the dredge, they are thrown ashore in tolerable perfection during storms. Of these the *Phyllophora membranifolia* may be cited, the fronds as much as a foot long when fully grown, the stem cylindrical, filiform, irregularly branched, the branches expanding into fan-shaped flattened membranous leaflets, the color a rich purple, inclining to livid, while that of the European species is scarlet. The *Gymnogongrus* which inhabits similar situations might be mistaken for the Chondrus, looking not unlike some variety of it, but its internal structure forbids this. Something like twenty kinds are known in the world, and the one most seen in this neighborhood is *G. Norvegicus*, having an extensive northern distribution.

These black tufts growing out of the stems of the larger algæ, and from the outside of shells, etc., belong to *Polysiphonia nigrescens*, of which the curious student could find a great many distinct varieties. A section of the frond would exhibit a number of tubes, side by side, composing the branch, and indeed the entire plant, and those tubes vary in

number, and yet seemingly not in a capricious manner, in different tufts. Though thus inelegant and vulgar or common, they belong to a refined and delicately educated family, having in their circle some of the prettiest algæ known in the American seas, of which the Venus' Comb (*P. pecten-Veneris*) found parasitic on corals and shells at Key West and the Pine Islands, is a notable example; and indeed all require only to be magnified to show what they are. There are numerous species to be looked up on the various sea-weeds and marine objects on which they delight to grow. This almost gelatinous mass of dissolving threads staining the paper with a deep empurpled or crimsoned blotch, is the *Dasya elegans*, more commonly met with to the south of Cape Cod; it is likewise a parasitic alga and grows in deep water; nor are other beautiful species unknown in distant regions. *Rhodomela* is worth looking for, being an elegant, much branched, filiform, cylindrical-stemmed alga, of which *R. subfusca*, *gracilis*, *Rochei*, etc., have been collected on the coast of Massachusetts. The several species belong to temperate zones. In the English manuals much is said of the beauty of the *Lawrencea;* in this country this alga is represented by the *Chondriopsis* of J. Agardh, and some may be sought, of which *C. Baileyana* is really elegant and graceful, while its conceptacle, or seed-vessel, is of classic outline, minute, yet not to be overlooked! Others similar might be alluded to, but we must defer mention of them, unless we meet them in their coral groves in waters of a higher temperature.

The broad-fronded rosy sea-weeds claim a passing tribute. Our beaches and shores, the resort of summer seekers for pleasure and profit, offer us the *Delesseria* with a genuine rosy-red, leaf-like, jagged edged, or else delicately branching membranous symmetrical frond, with a percurrent midrib. The seed-vessels are to be looked for near the midrib, but definite spots containing another sort of seeds occupy the surface or portions of the frond besides. Several species are found both north and south, but by far the finest is the *D.*

Americana, dedicated to Henry Grinnell of New York, in honor of his noble conduct in an expedition fitted out by him in search of Sir John Franklin, and known to American botanists as the *Grinellia* of Professor Harvey. In *Nitophyllum* we have a ribless frond, traversed by slender irregular veins; the frond broad membranous and variously divided, the seeds in the form of dots deep in the pulp of the leaf. *Calliblepharis ciliata* has the margins of its rich dark red frond beautifully ciliated or fringed; *Botryoglossum* and *Hymenena* are California species and can scarcely be looked for with any degree of success hereabouts. The *Rhodomeniæ*, with *Euthora*, are plants of great beauty, and need scarcely more than be named as the species are few; *R. palmata* is parasitic on algæ in shallow water; *R. palmetta* on the larger kinds in deeper soundings, and *E. cristata* extends in its range from the Arctic coast to Cape Cod.

Among the most abundant of these rosy-seeded algæ, and likewise of the most delicate structure, we notice the *Ceramiaceæ*, with fronds growing in close tufts, but sometimes solitary, creeping along the surface by fibres or affixed by disks, the stems slender, thread-like, articulated, dichotomously or pinnately branched, and sometimes growing so interwoven as to form network or spongy masses. In some species the space between the joints is diaphanous, which gives a strikingly beautiful appearance; in others the joints exhibit no such peculiarity. The species are exceedingly numerous, and the search for rarer ones in any given district would be compensating to him who does not despise trifles such as these at first seem.

The last of the Rhodosperms to which we invite your attention is *Callithamnion*, a very large genus of beautiful algæ, mostly small and many even minute, the different species difficult of determination, subject as they are to constant variation. The elegance of their several parts in stem, branches, and branchlets, the delicacy of their subdivisions, their exquisite color and the symmetry of the seed-vessels

in spite of the obstacles in correctly addressing them by their correct names, attract the attention of the most superficial. They are not difficult to find, and the same efforts to secure other and more specious kinds will insure many of these.

The Melanosperms, black or fuscous seeded sea-weeds, less comely and attractive but by far more useful to savage and civilized man alike, remain for a cursory glance at least. Although our species are of only a respectable size when compared with foreign kinds, yet they assist so much in producing the effect we witness, wherever the ocean impinges on the land, we can illy spare them. Investing rock and wood structures alike, if built in places subject to the variations of the tides, they bear exposure of a few hours to the dry atmosphere or scorching sunshine, and revive as the cooled waters return to cover them, forming safe retreats to fishes, mollusks and other marine creatures, and affording the most nutritious dressings by way of manure to the exhausted fields. The variety of forms which they present has caused them to be comprised in several families with subdivisions arranged in such a way that they can be more readily studied, and those will claim our notice. About our shores the most abundant sea-weed of this kind is the *fucus*, of which there are two or three species and several varieties; or according to Professor Harvey five species on the American and seven species on the European shores, and one allied to *F. nodosus*, found at the Cape of Good Hope. They are usually known as kelp weed, rock weed, etc. Their seeds are lodged in tubercles filled with mucus, and they are discharged through the small pores; the hollow vesicles by which they are buoyed up in the water are not the seed-vessels but air bladders. A section of one of these seed tubercles, under the microscope, affords an instructive and pleasing sight. The *Halidrys siliquosa* might be readily taken for a narrow fronded fucus, but the air vessels are singularly divided transversely by numerous diaphragms extremely thin and

membranous. It is usually found in shallow pools, but where the plant is never left to even temporarily become dry. Though very common on the Atlantic shores of Europe it does not seem to have been recognized here as growing on this side of the ocean. The *Cystoseira*, too, is only recognized as American in a California species though several are known to the British waters, and the *Phyllospora Menziesii*, detected by Menzies himself when with Vancouver, has elsewhere as yet only occurred in the deeper soundings of the California coast. In this plant we see the same globular air vessels we have noticed in the fuci. To this family belong also the gulf weeds, *Sargassum*, a vast genus and of which some species extend as near as Nantucket and Providence. One of them, the tropical Sea-grape (*S. bacciferum*), is seen floating in masses in the gulf stream, and is a familiar object. Kützing gives us a list of one hundred and three distinct species known over the globe!

An excessively branched and bushy mass of dark brown fibres, covered with short harmless prickles, and sometimes growing several feet in length, often presents itself on the sandy beaches, evidently torn from the bottom of deep water. This is *Desmarestia aculeata*, so variable in appearance at different stages of growth as to have led good botanists astray. When young, this otherwise stiff, bristly weed is clothed with the most delicate pencils of finely divided filaments, of a beautiful green color, a condition worth seeking. Its mode of bearing seeds is unknown.

Another natural order of the Melanosperms, comprising a great variety of kinds, is the *Laminariaceæ*, among which — from a simple cylindrical threadlike frond of the diameter of a whip-cord, and often twenty, thirty or forty feet in length, tapering at the extremity, and fixed at the base by a disk (*Chorda filum*) to a frond of broad dimensions, and supported by a long stalk (*Laminaria* or oar-weed) — we find a series of modified forms in species found in our waters. Of the sea leaf (*Thallasiophyllum*), one of this order, a writer

and naturalist thus speaks: "The ocean hardly boasts of a more beautiful production; it is generally about the height of a man, very bushy and branched, each branch bearing a broad leaf at its extremity, which unfolds spirally; a spiral border winds round the stem; a number of rather long, narrow perforations, arranged in a radiate form, give the frond the appearance of a cut fan; the margin is entire, its substance coriaceous, but liable to be torn. No seeds have been detected. This fine fucus, or sea-weed, is plentiful around the whole island of Amaknak, clothing the rocky shore like a thick hedge, and forming at a little distance a very pleasing feature in the scenery." (Mertens as quoted by Professor Harvey.) Though destitute of this wondrous sea-leaf, our piles of seawrack can display something similar in the highly curious sea colander (*Agarum Turneri*), which has come ashore after strong winds and gales. Furnished with a short, compressed, coriaceous stem, widening and flattening as it approaches the frond, and clasping by its stout fibrous roots the rocks and stones, its dark olive green expanded leaf perforated at short intervals with roundish holes, it is quite a respectable weed. The shores of Kamtschatka and the Pacific recognize others. Besides several kinds of the oar-weed of respectable dimensions, such as the Sweet or Sugar, the Long-shanked, the Fingered, with its frond deeply cleft into several strap-shaped segments, we have for noble sea-weeds *Alaria esculenta*, known, as articles of food, under the name of murlins among the peasantry of Scotland and Ireland, belongs to a small genus, inhabits the colder regions, and is recognizable by a branching root, stalked, membranous frond, with smaller fronds or leaflets springing from the stalk and below the main frond. A definite dark colored patch in the centre of these leaflets indicates the clusters of pear-shaped seed-vessels packed vertically among straight and simple threads.

From these we come by easy transitions to some of the most marvellous vegetable productions on our globe, and

algæ, or sea-weeds, too. How insignificant appear our kelp-weeds in comparison with the *Lessonia* of the Antarctic Zone, trees with forking and branching trunks covered with crimson brown, sinuated edged, and jagged-toothed leaves, or with blackish opaque foliage and twisted flexuous trunks, growing like submarine forests; or with the *Nereocystis* of the Aleutian islands, whose stem, never thicker than a packthread, extends to the length of forty fathoms or more, and expands at the summit into an inflated cylinder from which issues a leaf, which gradually grows wider near its top; not singly, not here and there a plant but areas of great extent covered with innumerable plants; or with the *Macrocystis* whose slender stem and numerous leaves are buoyed up by their expanded and swollen base, the stem so long that fifteen hundred feet has been reported by observers as within the limits of belief. These several kinds of expanded fronds are employed as utensils among savage people, while the trunks of many of these gigantic algæ drifting on desert shores have been mistaken and gathered for fuel, supposed to be actual wood.

The structural arrangement of the cellular tissue on a number of the Melanosperms, giving to their fronds a peculiarly netted appearance when viewed through a magnifying glass, suggests a natural order, called *Dictyotidæ*, which signifies like a net. Externally there is quite a variety among these sea-weeds, and of them we may search for *Punctaria* in two species, both parasitic on other and larger sea-weeds about Boston Harbor, or even *Asperococcus* with an inflated frond, while the others delight in a flattened one. The seeds may be found in the minute dot-like clusters scattered over the surface of the plants. To this order belong the curious *Padina pavonia* and its allied *Zonaria lobata*, bearing no inapt resemblance to those richly zoned and velvetty fungi which grow out of old dead tree-trunks; but both these lovely algæ are tropical and belong to our most southern states. The rest of the Melanosperms are either parasitic and minute, and to be gathered either accidentally or else

though strange and unusual in exterior, so infrequently that they hardly claim our present attention. In the structure of their seed-vessels and seeds they are objects of curious interest and beauty, but require a quick eye to detect the condition favorable to secure specimens, which when collected, must be submitted to the microscope to satisfy the enquirer.

If our excursion and lesson has convinced us that in the distribution of plants, the ocean, which to many, shuts out the chance of minute observation, forms no exception to the law of vegetation; each part of its vast bosom bearing, like the earth, its appropriate flowers, plants and fruits, a day or two among the sea-weeds will be well employed.

FOOT-NOTES FROM A PAGE OF SAND.

BY DR. ELLIOTT COUES, U. S. A.

If those whom fashion and the weather drive from city follies and vices to the vices and follies of the seaside; who live in hotels and carriages and fancy the society of their kind the only sort desirable or possible,—if such read at all by the sea shore, it is not from the broadest and most eloquent page before them. With eyes to see, blind; deaf, with ears to hear; to them, a blank, a void, beyond the titillation of social scandal. Others go out of doors afoot, looking and listening; in every object by their pathway a familiar thing; with every vibration of the air, a well known voice; with every odour a reminiscence. *Alone* by the sea? There is no solitude—no escape for the naturalist, even though in a weak moment he wish it, from a multitude—no disentangling of self from the web of animate creatures of which he is one slender thread.

The sea, we know, is teeming with life—full of shapes

useful or curious, beautiful or monstrous; the waves themselves, in ceaseless change, incessantly battling with the land, seem life-like; but the sand itself, solid and motionless, looks lifeless. The great broad sheet that stretches along the coast seems to be now, as it always has been, inanimate. A vast bed of silica; and yet if not alive, what a sarcophagus it is of myriad lives since perished! If the poet says of dust in the crack of a door, "Great Cæsar's ashes here!" and attach to the mote and the man common and equal significance, yet farther than this the naturalist; for him, not the greatest pile that ever rose over emperors' remains — not the pyramids,* tombs of Pharaohs, are so great, as this monument of life that Nature built — the simple sand. If ghosts be ever laid, here lie hosts, of creatures innumerable, vexing the mind in the attempt to conceive, never to compute, them; so minute that a grain of sand is prodigious beside. Creatures of wonderful, beautiful, varying shapes; creatures that ate and drank after their fashion and went on rejoicing or grieving till the day came. Let us write a name in the sand; the wave comes — the ebb, the cradle, — the flow, the grave — of such short-lived creatures; what to these then, that write their name in the "sands of time;" the coast of a continent their grave, the beach their monument, each sand-grain an epitaph.

How long this book has been making we do not know; no man's time will suffice him to turn and read even a single page. Reflection confounds; still we may stroll on, observant, if not thoughful; a letter, a point, an intelligible note, may catch the eye; and trifles enough have at least some pith. Say, at the moment, there is no living thing in sight. As a wave curls away from the mirrored sand, little bubbles play here and there for a few moments, and then too subside. Under the sand, where each bubble rose, lives a creature,

* And these too, are of a sort of limestone, called "nummulitic" because chiefly composed of vast numbers of certain Foraminifers (*Nummulites*). An ounce of Foraminiferous sand is estimated to contain upwards of four millions of these protozoans.

encased in shell armour, rarely seen alive, and scarcely known except by its casement, when this is thrown upon the beach; what some call a razor-shell, others *Solen ensis*. When the foot presses in yielding sand, surcharged with moisture, a slender jet of water spirts up; below is a clam (*Mya arenaria*); it dislikes the weight upon its elastic home, and remonstrates. There goes a groove in the sand, as if a child had wantonly dragged its copper-toed boot along, or some curious share had turned as curious a furrow; but the creature that made it has gone below, after what would have seemed to us, had we witnessed it, a tedious journey. Scattered here and there are large globular, yet essentially spiral, shells of the sea-snail (*Neverita heros*); the animal that lives in them made that mark, unfolding a great fleshy "foot," and gliding along, perhaps eating something as it went, with an organ that is mouth and limb in one. Where it is now, under the sand, are plenty more mail-clad things, of all shapes and sizes and colors; snug and secure, giving no sign of their presence. The sand is not only a great closet of foraminiferous skeletons; it is full of flesh and blood.

But we may look for signs from above as well as under the earth, or from the waters beneath; the sand tattles many pleasant, harmless secrets, if we only attend. Here are foot-notes again, this time of real steps from real feet; the next tide will wash them out; but perhaps some one of them, —the one chance of millions—may be left to signal, centuries hence, as much as they tell now. They are wedge-shaped, and meaningless as the cuneiform characters upon a Babylonic obelisk, unless the key to the cryptogram is found; for this, the lock must first be examined to the last detail, and it is surprising how many details there are. The imprints are in two parallel lines, an inch or so apart; each impression is two or three inches in advance of the next one behind; none of them are in *pairs*, but each one of one line is opposite the middle of the interval between two of the

other line; they are steps as regular as a man's, only so small. Each mark is fan-shaped; it consists of three little lines less than an inch long, spreading apart at one extremity, joined at the other; at the joined end, and *also* just in front of it, a flat depression of the sand is barely visible. So much: now following the track we see it run straight a yard or more, then twist into a confused ball, then shoot out straight; again then stop, with a pair of the foot-prints opposite each other, different from the other end of the track, that begun as two or three little indistinct pits or scratches, not forming perfect impressions of a foot; where the track twisted there are several little round holes in the sand. The whole track commenced and finished upon the open sand. The creature that made it could not, then, have come out of either the sand or the water; as there are no fire-animals now days, it must have come down from the air; a two-legged flying thing — a bird. To determine this, and next, what kind of bird it was, every one of the trivial points of the description just given must be taken into account.

It is a bit of autobiography; the story of an invitation to dine, acceptance, a repast, an alarm at the table, a hasty retreat. A bird came on wing, lowering till the tips of its toes just touched the sand, gliding half on wing, half a foot, until the impetus of flight was exhausted; then folding its wings, but not pausing, for already a quick eye spied something inviting; a hasty pecking and probing to this side and that, where we found the lines entangled; a short run on after more food; then a suspicious object attracted its attention; it stood stock-still (just where the marks were in a pair) till, thoroughly alarmed, it sprang on wing and was off. So much is perfectly plain and intelligible; it may be not quite so easy to find out what the bird was, for we will shut the "back-stairs" door and allow no guessing, but go honestly about our induction, as if we only knew of dead birds in the closet, and had never seen a live one.

Each foot-print was of three marks only; clearly then made by a three-toed bird; or, if by one with four toes, the fourth was too short to reach and impress the ground visibly, or else was joined to the leg too high up. The three marks all point forward; then the hind toe, or *hallux*, as it is called, was the missing or rudimentary one. Now, unless the bird was of a kind unknown to naturalists, which is highly improbable, it must have belonged to one or the other of two groups—the Walkers and Waders, or the Swimmers—named, respectively, *Cursores* and *Natatores*, since no bird of the only other remaining group (*Insessores*) has none, or a rudimentary hind toe.* Birds, however, cannot swim unless their feet are fashioned into paddles of some sort. We only know of this being done in two ways: either by stretching a membrane between the toes, making a webbed foot, or by fringing of the toes by broad membranes, making a lobed foot. But either of these feet, pressing the glassy sand, would have shown its pattern. Clearly then the bird was neither palmiped or lobiped—it was not one of the *Natatores;* it must have been a Wader. Other reasoning, from a different premise, brings us to the same conclusion. The marks were not in pairs, but alternating, each with its fellow of the other line; the bird did not hop or leap, but walked or ran bringing one leg after the other, whence we legitimately infer that it was not one of *Insessores* or Perchers; for these hop. But it might be asked, how do we know that the perchers hop instead of walking when on the ground, since we are agreed that we never yet saw a live one to find out by observation? Yet it is easy to reason up to such a point, that assumption is virtual certainty. For the hind toe (or each hind toe when there are two) of the *Insessores* is long, is inserted on a level with the anterior ones, and is armed with a curved claw as the others are. This arrangement is

* To this and all other unqualified general statements in ornithology there are technical objections and real or apparent exceptions, not, however, invalidating general rules.

for the perfect opposition of the hind and front toes, as the thumb of our hand opposes the fingers; it infallibly suggests the idea of something to be clasped between—of grasping some object; the suggestion amounts to a moral certainty when we dissect and find among typical perchers a special muscle for the freer and more advantageous working of this hind toe in opposition to the others. Such birds then, live where their foothold is not upon a flat surface, as the ground, but upon slender, cylindrical, claspable supports, as are found in trees and bushes. But there cannot be much plain walking done among twigs; the birds must constantly spring from one to another branch, and when they happen to descend to the ground it is not likely they would at once change a habit inborn and inbred for ages. So with certain exceptions, not necessary to point out here, *Insessores* are hoppers, as distinctively as all birds below them are either Walkers or Swimmers.

This bird's wings never touched the sand, yet the marks show the shape of the wing as plainly as the character of the feet. The wings were flat, long, narrow and pointed, cutting the air like blades. We learn this from the few indistinct scratches on the sand just before the prints became perfect. The bird came gliding swiftly and low, and scraped the sand before its wings were closed; to do this requires a wing large or at least long. For all heavy bodied birds, or birds with wings small for their weight; or with short, rounded and concave wings—all these, however fast they may whirr along when fairly on wing, must drop quietly, if flying slowly, or arrest their motion abruptly and forcibly, if flying rapidly, to avoid shock on alighting; in either case they drop plump, and find their feet at once. Now of all our true walking or wading birds the *Gallinæ* (Grouse, Quail, etc.) and the *Paludicolæ* (Rails and Gallinules) conform to these last mentioned particulars; so does the Heron family, and these, moreover, have a long hind toe. It could have been neither of these. The circle of possibili-

ties is rapidly narrowing; we have only left whence to pick, the families of birds that make up the group *Limicolæ*, or the shore-waders, as distinguished from the *Paludicolæ*, or marsh-waders. Conning the *Limicolæ* over in mind, we fine there are but two families furnishing in our locality any species so small that the imprint of its toes is less than an inch long. These are the Plover and the Snipe families (*Charadriidæ* and *Scolopacidæ*).

We noticed just in front of the point where the lines of the three toes came together—at the "heel," as it is generally but wrongly called—that the depression of the heel-mark continued a slight distance between the bases of the toes. Clearly there must have been something of a web connecting the roots of the toes, just as our fingers are joined at the hand. Now our plovers and snipes each furnish us one, and only one, bird that is partially webbed and small enough to have made the tracks; these two are the Semipalmated or Ring Plover (*Ægialitis semipalmatus*) and the Semipalmated Sandpiper (*Ereunetes pusillus*); it might have been either, for anything we have yet noticed. Which was it? We have exhausted our foot-data, but still one mark is left, and that decides. The snipes have long bills, vascular, nervous, and sensitive at the tip; these are organs of touch; the birds *feel for* things they cannot see. The plovers have short bills, comparatively hard at the tip. There were little round holes in the sand, just where the lines tangled up; this was where the little bird stuck in its bill and probed for something. It would be useless for a plover to do this, for it could not *feel* anything if it did; we infer then, that a plover never would. And so at last, the bird stands confessed; Semipalmated Sandpiper, *Ereunetes pusillus*; section *Tringeæ*, of family *Scolopacidæ*, of group *Limicolæ*, of order *Grallæ*, of subclass *Cursores*, of class *Aves* or BIRDS.

REVIEWS.

SPONGES.*—Professor Hæckel in this paper has condensed the results of an extended and very remarkable series of investigations with regard to the affinities of the Sponges.

He places them nearest the corals, considering their canal system as homologous with the stomach and circulatory system of the corals. He farther identifies their structure by showing that in both of these types the primitive body wall consists of two layers, an outer homogeneous, which however, springs from an originally cellular layer, and an inner cellular membrane. This comparison is carried so far that as in the Cœlenterata (Acalephs and Polyps) the large vessel, which conveys away the water admitted through the sides by the smaller branches permeating the mass of the sponge, is called the stomach. Sponges are also stated to be either simple or compound, to be composed of one or more individuals in proportion as they have one or more afferent openings. Of course Professor Hæckel is well aware of the principal objections to his theory, and states them. The mouthless sponges, for instance, he accounts for by referring to the mouthless Sycocystis, which, however, has young with a well formed mouth. The fact, however, that the water permeating the sponge-body goes through minute apertures in the wall itself and is ejected at the so-called mouth, is not encountered with quite the same success. The cutaneous pores of the corals are supposed to be the same as these minute pores, and are supposed to perform the same or a similar office for the animal. The egg of the sponge (Prosycum) is said to pass through the mulberry condition, after which it becomes hollow and clothed with cilia. This cavity enlarging finally breaks through one end, and forms a mouth opposite to the end which has already become attached to the rocks. At this young stage it is said to be not essentially different from a fresh-water Polyp, or a young coral.

The author nowhere alludes to the late memoir of Prof. H. J. Clark, the most conclusive of any that has yet appeared, advocating the compound nature of the sponge. In this memoir it is clearly shown that in Leucosolenia, a marine sponge, the cells of the inner membrane lining the cavity (stomach of Hæckel) are monads and not true cells. That they have the single flagellum surrounded by a vail, or calyx, and contained contractile vesicles and particles of food in various states of digestion. Carter's observations, as well as Professor Hæckel's, distinctly confirm the flagellate, or single-haired, condition of the cells of the internal membrane, and the structureless, gelatinous nature of the external layer.

* On the Organization of Sponges and their relationship to the Corals. By Ernest Hæckel (Translated in the Ann. and Mag Nat. History Jan., 1870, from the Jenaische Zeitschrift B. v. p. 207).

Professor Clark found that the monads, hitherto considered one of the simplest forms of animal life, had a similar flagellum, but that this was used to procure food, which he distinctly saw as it entered the sac-like body through a mouth situated at its base. The lip of this mouth spread itself over the morsels which descended into a digestive vesicle in the interior of the body. The series from this point to the sponge is completed by a form, Salpingœca, which with the same characteristics also secretes a gelatinous envelope. These anatomical facts fully justified the author of the memoir alluded to in claiming that he had discovered the true nature of the sponges, and they appear to indicate a much closer affinity between the sponges and the Uniflagellate Infusoria, and appear much more decisive than the coral-like characteristics described by Professor Hæckel.

The comparison of the aquiferous systems of sponges with the true stomach cavity and circulatory vessels of the coral is more than doubtful. The objection that the current flows in opposite directions cannot be met by comparing the perforations of the body wall in corals with those of sponges. It is well known that these perforations are common also in the star fishes and Polyzoa, and their precise import in either is as yet unknown. The most rational view would seem to be the opposite of Hæckel's, *i. e.*, that the pores are the mouths, and the so-called mouths the anal orifices, since out of these is all the refuse of the body thrown. Describing the radiating canals of Cyathiscus, the author asserts that the horizontal walls which divide these canals are absorbed, and the vertical walls are left standing, and thus a series of radiating chambers are produced, similar to those of the corals. Farther, that the only difference between them is that in corals the central stomach opens below into the common cavity, into which also the radial chambers open, and in Cyathiscus the stomach opens directly into the radial chambers by series of vertical pores, the former mouths of the lateral canals. This is perhaps the very strongest evidence brought forward by Professor Hæckel, and it is certainly a most interesting and remarkable fact, but seems hardly conclusive. The formation of the radiating partitions in the corals by the infolding of the inner membranes of the walls, is a very different process from that described above in Cyathiscus. How can we account for the fact that an individual with a large stomach cavity, and a set of circulatory vessels, has arisen when no useful end whatever could have been secured thereby? What useful end, or of what advantage is it to the species as an individual to possess numerous minute pores to admit food and rapidly enlarging canals, abutting finally in a large trunk to facilitate its emission. This is just the reverse of the economy of the organization of every individual, as such, in the animal kingdom. Individuals are universally possessed of facilities for obtaining and swallowing food in the shape of large pliable mouths and stomachs, whereas the emission of the refuse takes place through the smaller end of the canal or through the mouth again.

For the proper support of an individual it is evidently necessary that the food, whether microscopical in size or not, should be obstructed in its passage through the body and subjected to a thorough process of digestion. According to Professor Hæckel, however, we have in the sponge a creature in which all this is reversed, and a digestive system is presented to us which is perpetually increasing its facilities for getting rid of food as fast as it is swallowed. How this reversal of the animal economy can be of service to the race we cannot see, so long as we regard the sponge as an individual, or an aggregation of large individuals; but if on the other hand we adopt the opinion of his opponents, then all these difficulties disappear. We then see that the pores act as a strainer admitting only bodies of small size, such as are appropriate for the sustenance of the monads, which cover the internal surfaces of the canals. The gradual enlargement of these canals into a central trunk becomes at once appropriate, when we compare it with the similar facilities which are found in all compound communities for relieving the colony of refuse and deleterious matters. The fact noticed by the author, with marked emphasis, that each cell of his entoderm (internal membrane), is armed with a single flagellum is also explained, and the vase-like form of these cells noticed by Carter, and the amœba-like character of the external membrane, accords equally well with this view. We do not find in this article in fact any remarks which lead us to think that Professor Hæckel has paid such full attention to the structure of the single cells of his inner membrane as would justify him in adopting an opinion so entirely opposed to that which we have advocated. Of course in his forthcoming work this point may be more fully treated of; and since the whole discussion hangs upon a question of fact as regards the structure of the single cells of the internal membrane we may look for an early solution of this vexed question.

If we dropped the review here it would be treating Professor Hæckel with great injustice. Though forced to criticise the main point of his theoretical deductions, the studies upon which they are founded, like the other works of this eminent German zoologist, will be deeply felt in the history of the progress of knowledge in this department.

The account of the function and structure of the ectoderm, and of the development of the "ova" from special forms of his so-called cells of the internal membrane are of the greatest interest and importance. That, also, of the gradual development of the canal system gives us an entirely new and original view of sponge structure. In this connection the remarkable statements are made that species of Nardoa, Nardopsis and Cænostoma begin with a single stock which subsequently branches, only however to coalesce again as they approach maturity and unite their various apertures into one common trunk and single aperture; and also, that we can trace the origin of a species from the common stem form. To illustrate this last assertion the author instances two species, *Guancha blanca* and *Sycometra compressa*, whose variations are so great, and indi-

cate affinities, with so many different groups, that he has been obliged to place them in a separate order by themselves. "*Sycometra compressa appears as a sponge stock which bears upon one and the same cormus the mature forms even of eight different genera.*"

In conclusion Professor Hæckel begs all of his readers who may be in possession of specimens of calcareous sponges to send them to him for examination and comparison.

THE EXTINCT MAMMALIAN FAUNA OF DAKOTA AND NEBRASKA.* — This important work is the final expression, the author informs us, of labors extending over a period of twenty-three years, during which the materials on which it is based, have been accumulating. Sufficient time has elapsed to allow of corrections of first identifications, and we have the result in a memoir of much completeness and accuracy in the topographical descriptions of the remains preserved in such unusual perfection and abundance in the localities in question. Fortunately the Academy of Natural Sciences of Philadelphia numbers among its members liberal minded men of wealth, for without the "sinews" of the undertaking furnished by Messrs. Joseph Jeanes and William P. Willstach, this work would not have seen the light. As it is, the execution both in printing and lithography, is a credit to all concerned.

The species hitherto discovered in the Bad Lands belong to two series of strata, determined many years ago by Dr. F. V. Hayden to be Miocene and Pliocene respectively. Fossils from these, and a few of Postpliocene age are included, derived from the area in question. The whole number described is eighty-six, distributed as follows: Carnivora, fifteen; Artiodactyla, thirty-four; Perissodactyla, twenty-nine: Rodentia, six; Insectivora, two. With reference to the relations of the genera and species, we let the author speak, by quoting his valuable summary at the close of the descriptive portion of the work:

"In comparing the two lists representing the North American tertiary mammals, mainly from the states of Dakota and Nebraska, with the third list representing the quaternary mammals of the same continent, a remarkable dissimilarity is observed, and there is also noticed a greater resemblance of the former with the tertiary and quaternary mammals of the old world.

Of thirty-two genera of miocene terrestrial mammals, chiefly from the Mauvaises Terres of Dakota, not one occurs in the quaternary formation of North America; and of twenty-one genera of pliocene terrestrial mammals, chiefly from the Niobrara River of Nebraska, only eight are common to the quaternary formations of North America, and of these eight three are absent in the existing fauna of the continent. The eight genera alluded to as common to the pliocene tertiary and the quaternary formations are Canis, Cervus, Dicotyles, Mastodon, Elephas, Equus, Hipparion and Castor.

It is uncertain how far the species of Canis attributed to the Niobrara pliocene formation are peculiar to it. Part of the fossils may be quaternary, or perhaps, even recent remains. Of Cervus, part of the specimens referred to it may be of a recent species, while the antler viewed as pertaining to the same may represent a peculiar genus, subsequently extinguished. The only remains indicative of Dicotyles was an upper canine tooth which may really have belonged to a quaternary or perhaps a recent species. The remains of the pliocene mastodon

* The Extinct Mammalian Fauna of Dakota and Nebraska, with a Synopsis of the Mammalian Remains of North America. By Joseph Leidy, M. D., LL. D., preceded by an Introduction on the Geology of the Tertiaries of Dakota and Nebraska, by Professor F. V. Hayden, M. D.

pertain to the subgenus Tetralophodon, while those of the quaternary period belong to the subgenus Trilophodon.

The remains of Elephas probably indicate a species distinct from the quaternary *E. americanus*, though it is not positively ascertained. The remains of Equus appear to be different from those of the later *E. fraternus*. The genus Hipparion is clearly common to both the pliocene and quaternary period, but the species are different. Protohippus, one of the solipedal genera of the Niobrara pliocene, appears also to have existed during the quaternary period, in Chili, South America. A small species of Castor, of the Niobrara pliocene, is represented by the larger quaternary and still existing Beaver.

The quaternary fauna of both American continents was especially distinguished by the presence of those wonderful creatures, the giant sloths, no trace of which has been detected in the tertiary formations of North America. This appears the more remarkable from the circumstance that remains of several edentate genera have been discovered in the miocene formations of Europe.

The presence in the quaternary fauna of North America of the great sloths, together with other ordinal and generic forms, which likewise existed, and in part still continue to exist, in South America, leads to the impression that the North American continent during the quaternary period was peopled by the extension of life from the south. The greater similitude of the miocene and pliocene faun e which we have investigated in the present work, with the contemporaneous faunæ of the old world, suggests the probability that the North American continent was peopled during the tertiary period from the west. Perhaps this latter extension occurred from a continent whose area now forms the bottom of the great Pacific Ocean, and whose tertiary fauna is now represented east and west by the fossil remains of America on the one hand, and of Asia with its peninsula, Europe, on the other.

In comparing the miocene and pliocene faunæ with each other, as represented mainly by the remains from the Mauvaises Terres and the Niobrara River, we observe the remarkable fact that in upwards of fifty genera belonging to the two faunæ together, scarcely a genus is common to both. In view of the consecutive order and close approximation in position of the two formations and faunæ, such an exclusiveness would hardly have been suspected.

Thus, for instance, the pliocene Merychyus may be regarded as identical generically, with the miocene Oreodon; but after all these are the only ones which could be looked upon as the same, unless perhaps Rhinoceros is included. In this case, however, the miocene *Rhinoceros occidentalis* appears to have been an Aceratherium, while that of the pliocene formation was probably a true or horned Rhinoceros.

Of all other known faunæ, extinct and recent, those of Dakota and Nebraska, under consideration, appear to approximate most in their relationship with the tertiary faunæ of Europe.

Of the carnivora of the former localities, comprising eight genera and fifteen species, five of the genera, or more than one-half, are found in the European tertiaries, as for instance: Canis, Amphicyon, Hyænodon, Pseudælurus, and Drepanodon. The feline Dinictis of the Dakota miocene has not elsewhere been discovered. The remaining two carnivorous genera are too imperfectly known for comparison.

It is truly wonderful that of the numerous Ruminantia, comprising fourteen genera and nearly double that number of species, none, excepting the genus Cervus, belongs to any other known fauna extinct or recent. Even in the case of the excepted genus, it is probable that part of the remains attributed to it may belong to a peculiar subgenus, while others may be of a recent species.

When we compare the family relationships of the North American tertiary and quaternary ruminants, we find remarkable differences. A peculiar family, the Oreodontidæ, is represented in both the miocene and pliocene; in the former by three genera and many species, in the latter by a single genus. This family has nowhere else been discovered, neither in the American quaternary nor the foreign tertiary equivalents.

Another family, the Agriochœridæ, nearly allied to the former, is peculiar to the miocene of the *Mauvaises Terres*.

The Camelidæ are represented in the North American miocene pliocene and quaternary deposits, but particularly in the miocene, and they are yet represented in the existing fauna of South America.

The Moschidæ are represented by the genus Leptomeryx in the Dakota miocene, but not in the later formations of North America.

The Cervidæ are represented in the pliocene and succeeding epochs in North America. The Antilopidæ are represented by a genus in the Niobrara pliocene. The Capridæ and Bovidæ are not represented in North America prior to the quaternary period.

Of Artiodactyla exclusive of the Ruminantia, the remains of seven species of six genera belong to the Dakota miocene, of which two genera, Elotherium and Hyopotamus are common to the European tertiary. The remaining genera in part but imperfectly known, appear to be peculiar. The Niobrara pliocene presents us with traces of a peccary, but this probably may belong to a later period.

One of the artiodactyle genera of the Dakota miocene, the huge Titanotherium, was represented by the nearly allied Chalicotherium of the European and Himmalaya miocene period.

Of uneven-toed Pachyderms or Perissodactyla, the Dakota miocene presents one Aceratherium, a peculiar genus of the same family, the Hyracodon, and a species of Lophiodon. The former and latter are both European tertiary forms. Another member of the Rhinoceros family, *R. hesperius*, from California, was probably an Aceratherium of miocene age. *R. meridianus* of Texas was probably of the same category as the latter.

The Niobrara pliocene presents us with three genera, Rhinoceros, Mastodon and Elephant. The former has not been found in the American quaternary, though abundant in its European equivalent, and continuing to exist in Asia and Africa. The Mastodon belonged to the subgenus Tetralophodon, while that of the quaternary period was a Trilophodon. Elephants of other species were nearly cosmopolite during the quaternary period; but two species now live in Asia and Africa.

Five genera of Solipeds appear to have lived in North America during the miocene period. Three of them are peculiar, and appear not to have been discovered elsewhere. They have been named Anchippus from Texas, Hypohippus from the Niobrara River, and Anchippodus from New Jersey. The remaining genus Anchitherium, characterized by an abundance of remains from the Mauvaises Terres belongs also to the European miocene.

The pliocene formation of the Niobrara is remarkable for the abundance of its equine remains, which have been referred to five genera, of which Merychippus and Parahippus are peculiar, and Protohippus has been discovered elsewhere only in South America. The remaining genera Hipparion and Equus belong also to the North American quaternary and likewise to the European quaternary and tertiary formations.

The miocene Rodents of the Mauvaises Terres belong to four peculiar genera of as many still existing families. One of the genera, Palæocastor, may be identical with the European chailcomys of Cotemporaneous age.

The pliocene Rodents of the Niobrara appear to belong to the still existing genera Castor and Hystrix, but the latter now exists only in the old world.

Of the few discovered quaternary rodents of North America, one genus, *Hydrochœrus*, now absent on this continent, still lives in South America.

The miocene Insectivora of North America belong to three genera not discovered elsewhere." pp. 359-362.

In reviewing the character of the work, the care and accuracy of the descriptions furnish a most valuable storehouse to the palæontological student of other strata or localities, and its conscientiousness in this respect constitutes its great merit. On the other hand, however, we fail to find in many cases, that exact comparison and clear diagnosis of genera proposed or adopted, by which the zoological affinity is alone expressed, and by means of which the analysis of the subject in the broad sense is so greatly facilitated. Without it, the student gropes in a mass of detail, and unless he fortunately have access to a good museum, will fail of acquiring a mastery of it. This refers also to a precise comparison with European genera, for which we have so many standards in figures and descriptions.

The synopsis of extinct mammalia is of equal or greater value to the student. The whole number of species enumerated is two hundred and three, of which Dr. Leidy has stood sponsor to one hundred and twenty. The species are distributed into the orders as follows: Carnivora, thirty-three; Artiodactyla, fifty-two; Perissodactyla, thirty-seven; Rodentia, twenty; Insectivora, five; Marsupialia, one; Edentata, seven; Sirenia,

two; Zeuglodonta, two; Cetacea, forty-four. There are several species described for the first time, and the literary references are very complete. The system adopted by Dr. Leidy requires some comment. He adopts the order Bimana, a step which we regard as retrograde, since modern investigations, fresh in the mind of every student, have proved beyond cavil that that group is subordinate to the order Quadrumana. The division of Artiodactyla into Ruminantia and Artiodactyla as orders, ranking with other groups so-called, on the presence or absence of the functional peculiarity of rumination, is also contrary to the philosophy of a homological system. The separation of the Pinnipedia from the Carnivora has in the same manner little better foundation. The adoption of the Zeuglodonta as an order is perhaps a step forward, though in that case the Squalodons, which embrace ten of the twelve species included, must certainly be referred to the Cetacea. The separation of the Sirenia as an order has met with favor from Owen and others, and is well adopted in the present work.

The Earliest Evidences of Plant-life.* — In this pamphlet Professor Dawson reviews the different substances which have been supposed to show that plants existed contemporaneously with the Eozöon in the Laurentian of Canada.

"We may sum up these facts and considerations in the following statements: — First, that somewhat obscure traces of organic structure can be detected in the Laurentian graphite; secondly, that the general arrangement and microscopic structure of the substance corresponds with that of the carbonaceous and bituminous matters in marine formations of more modern date; thirdly, that if the Laurentian graphite had been derived from vegetable matter, it has only undergone a metamorphosis similar in kind to that which organic matter in metamorphosed sediment of later age has experienced; fourthly that the association of the graphitic matter with organic limestone, beds of iron ore, and metallic sulphides greatly strengthens the probability of its vegetable origin; fifthly, that when we consider the immense thickness and extent of the Eozoonal and graphitic limestones and iron-ore deposits of the Laurentian, if we admit the organic origin of the limestone of graphite, we must be prepared to believe that the life of that early period, though it may have existed under low forms, was most copiously developed, and that it equalled, perhaps surpassed, in its results, in the way of geological accumulation that of any subsequent period."

Fossil Birds.† — In this little pamphlet Professor Marsh imposes a new obligation on the science of Paleontology, by the discovery of five species of Cretaceous birds. Among the species there is one, *Paleotringa vetus*, described from the original specimen found by Dr. Morton. This is the first fossil bird bone found in this country, and though referred to by Dr. Morton in his Organic Remains of the Cretaceous period, has been hitherto considered a recent specimen, which by some accident had been buried in the Cretaceous marl deposits. The forms embrace one large swimming bird (*Laornis Edwardsianus*), two gulls (*Palæotringa littoralis*

* On the Graphite of the Laurentian of Canada. By J. W. Dawson, LL. D., etc. Proceedings of the Geological Society, Postponed Papers, Vol. xxvi, Part 1. Pamphlet, pp. 5.

† Notice of the Fossil Birds from the Cretaceous and Tertiary Formations of the United States. By Professor O. C. Marsh. From American Journal of Science and Arts. March, 1870. Pamphlet, pp. 16.

and *P. vetus*), and two rails (*Telmatornis priscus* and *T. affinis*). Besides these there are descriptions of four species of Tertiary birds, the first that have been regularly described from that formation in this country. These are said to be more closely allied to existing species than those of the Cretaceous. They are *Puffinis Conradi*, *Catarractes antiquus*, *Grus Haydeni*, and *Graculus Idahensis*.

Though the discovery of that remarkable bird, the Archæopteryx, in the Jurassic beds, led naturalists to suppose that Cretaceous forms would be eventually discovered, to Professor Marsh's energy we owe the fulfilment of these anticipations.

NATURAL HISTORY MISCELLANY.

BOTANY.

Hibernation of Duck-weed. — It has long been known that some species of *Lemna*, or duck-weed, produce, at the approach of winter, leaves of a different character to those formed in the spring, which fall to the bottom of the pond or stream, enabling the plant to live through the winter. A series of more accurate observations on this point is recorded by M. Van Hoven in the "Bulletin de la Société Royale de Botanique de Belgique." The species of *Lemna* indigenous to Belgium are the same as those found in this country; of these M. Van Hoven finds that two only, the *L. polyrrhiza* and *gibba*, produce leaves of a different form in winter; while with the three other species, *L. minor, trisulca*, and *arrhiza*, the ordinary leaves live through the winter, remaining on the surface. In *L. polyrrhiza* these winter-leaves first make their appearance in August or September. They are much smaller than the ordinary leaves, reniform or sometimes elliptical, olive-brown on both sides, and not gibbous beneath; their roots are exceedingly minute, and at first hidden within the leaf. The aëriferous cells which serve to support the ordinary leaves on the surface do not exist, causing the winter leaves to resemble an undeveloped bud. In consequence of the absence of these vessels they are heavier than the water, and fall to the bottom as soon as any agitation of the water detaches them from the parent leaf, which perishes with the first frost. At the ordinary period of the revival of vegetation, a small bubble of oxygen appears on the upper surface of these submerged leaves, which carries them to the surface, from which they again descend should the temperature fall below a certain point. In *Lemna gibba*, leaves of a similar character were observed hibernating beneath the water, differing in shape, size, and structure from those developed during the summer. — *Quarterly Journal of Science.*

THE FRAGARIA GILLMANI AGAIN.—In simple justice to those concerned, I think it but right to state that specimens of this strawberry have lately been examined by Dr. Asa Gray, and that he confidently considers it *F. Mexicana* Schlechtendal. At the same time he admits that Schlechtendal in his description has omitted all mention of the well-developed leaf on the scape, which Dr. Gray allows, "proves to be, or to be connected with, the distinguishing character of the species," adding that "no one could tell from Schlechtendal's description whether or not he had a plant like this in view." It will thus be seen that he does not entertain the idea that it is merely "an accidental variation of *F. vesca*," as some would have made it, and that whether it is a new species or not, it is one not hitherto described, or at least not sufficiently so for identification.

In view of the interest at present manifested in England in regard to the *Everlasting Andine Strawberry*, and the discussion as to whether it would retain its perennially fruitful habit, I would state that the Mexican everbearing strawberry (*F. Gillmani* Clint.) has held this everbearing character for ten years in the State of Michigan. Plants removed to the house from the open ground last January are now (March 22d, 1870) in fruit. The plant has been raised from seed during the past season, and the seedlings continue to produce all the characteristics of the parent plants, with dichotomous stem and racemose flowers, even to the blossoming and fruiting of the stolons, and that when but four months old! — the leafy character of the stem being a marked feature. — HENRY GILLMAN, *Detroit, Michigan.*

VITAL FORCE AND COLOR IN PLANTS. — In my remarks on the yellow-flowered variety of the purple Sarracenia, in the March number of the NATURALIST, the parenthesis, on page 44, contains an evident *lapsus pennæ*. Instead of reading "(white being taken as absence of color)," it might be corrected and improved so as to read as follows: — "(white being taken as accession of color and diminution of vital force.)" It has been repeatedly demonstrated that plants with variegated leaves, such as are so greatly sought after at present, are much more delicate than their plainer brethren, which, with less color, require less protection. This, I believe, is well understood by nurserymen who govern themselves accordingly. A multitude of facts are, day by day, grouping themselves about this interesting subject, and more clearly defining the laws which govern it. As we better understand the effects on vegetation of different mineral constituents of the soil, more light will be shed in this direction.

It has been remarked that when a flower is of two colors, they are almost always complements of each other. Familiar instances of this are the forget-me-not and the autumnal asters. More beautiful instances are the fairy bird's-eye primrose of the rocks (*Primula farinosa* Linn.), bearing pale lilac blossoms with yellow eyes, powdered with silvery farina, and the peerless calypso, nymph of the hemlock groves (*Calypso borealis* Salisb.), with brilliant purple petals, and lip maculated with a darker purple, almost hiding the flush of rare yellow glory within. Where there

are three colors, the third is commonly white, — the union of the other two, as it were. A fine illustration of this is seen in the showy moccason-flower (*Cypripedium spectabile* Swartz.). The snow-white petals spread above the inflated lip of as perfect a white melting into pink, which in turn, deepens into purple in front; while, drooping into the cavity, depends the singular petal-like sterile stamen of a pale lemon-color blotched with tawny spots. Another elegant example of this is presented by the *Calopogon pulchellus* R. Br., the club-shaped hairs in the beautiful beard of which are pure white, bright yellow, and rich purple. The white is distributed, if we may use the expression, into yellow and purple. — HENRY GILLMAN, *Detroit, Michigan.*

THE LIANIS OR WOODY CLIMBERS of the Isthmus, form, as is well known, entangled obstructions in the forests, which can be penetrated only by aid of the axe or *machete*. M. Lévy, a botanical traveller in Nicaragua, sends to the "Bulletin of the Botanical Society" of France (Nov., 1869) an interesting account of them. The stems send out aerial roots freely, many of which reach the ground, when they enlarge in diameter and form new trunk-like supports. When cut in two the lower end of the severed stem sends down a root to rëestablish its connection with the ground. M. Lévy, finding one in this condition from which hung roots a foot long, cut it off anew; two days afterwards it had produced new roots of the same length. Cutting it again it promptly made new roots, but more slender ones. He repeated the operation up to the eighth time, but the new roots were now so slender and feeble that he desisted. The plant was a species of *Bignonia*.

JAPANESE SEA-WEEDS. — At a recent meeting of the Royal Academy of Amsterdam, a collection was exhibited to illustrate the care taken by the Japanese in applying to beneficial purposes the natural products of their country. The collection consisted of sixteen species of algæ which are useful for food or other purposes, together with fabrics manufactured from some of them. Several of the species were altogether new; in other instances the application was entirely novel. — *Quarterly Journal of Science.*

ZOOLOGY.

A NEW INSECTICIDE. — M. Clocz, who is engaged at the garden of the Paris Museum, has invented what he considers a complete annihilator for plant-lice and other small insects. This discovery is given in the "Revue Horticole," with the endorsement of its distinguished editor, E. M. Carrière. To reduce M. Clocz's preparation to our measures, it will be sufficiently accurate to say, take three and one-half ounces of quassia chips, and five drachms of stavesacre seeds, powdered. These are to be put in seven pints of water, and boiled until reduced to five pints. When the liquid is cooled, strain it, and use with a watering-pot or syringe, as may be most convenient. We are assured that this preparation has been

most efficacious in France, and it will be worth while for our gardeners to experiment with it. Quassia has long been used as an insect-destroyer. The stavesacre seeds are the seeds of a species of larkspur, or Delphinium, and used to be kept in the old drug stores. Years ago they were much used for an insect that found its home in the human head, but as that has fortunately gone out of fashion, it may be that the seeds are less obtainable than formerly. The stavesacre seeds contain Delphine, which is one of the most active poisons known, and we have no doubt that a very small share of it would prove fatal to insects. — *Scientific Opinion.*

Fauna of Round Island. — The remarkable discovery has been made by Sir H. Barkly, Governor of Mauritius, of four species of snakes and several species of lizards, in Round Island, a small island twenty-five miles from Port St. Louis, and separated by a sea only four hundred feet deep, no animals of that description being natives of the Mauritius. The flora was also found to be to a great extinct specifically distinct. — *The Academy.*

Position of the Brachiopoda in the Animal Kingdom. — For some time past the writer has had reasons for believing that the Brachiopods, with the Polyzoa, had greater affinities with the worms than with the mollusks. He has studied attentively *Terebratulina* and *Discina* as well as their early stages, and in all points of their structure interprets articulated characters, and not molluscan characters. Without entering into particulars at this time, he would state that in the structure of the shell he finds the greatest resemblance to the shell of crustacea, both as regards the peculiar tubular structure, and the scale-like appearance, and its chemical composition. In *Lingula*, while the carbonate of lime amounts to only six per cent., the phosphate of lime amounts to forty-two per cent.

The horny setæ which fringe the mantle are remarkably worm-like. In worms the bristles are enclosed in muscular sheaths, while in other articulate animals the hairs are simply tubular prolongations of the epidermal layer. In the Brachiopods these bristles are secreted by follicles and are surrounded by muscular fibres, and are freely moved by the animal. The structure of these setæ differ but little, if at all, from those of the worms.

The lophophore with the cirri is to be compared to similar parts in the tubicolous worms, and the mantle which covers and conceals their arms, is to be compared to the cephalic collar, as seen in Sabella, for instance, where we find it split laterally, and a portion reflected. If this were greatly developed so as to cover the expanded fronds of cirri, we should recognize quickly the relation between the two.

Dr. Gratiolet has compared the circulatory system of the Brachiopods to that of the crustacea, and Burmeister has shown a resemblance between the respiratory apparatus of certain cirripeds and that of Lingula.

In the reproductive system there is a close similarity existing between the oviducts of Brachiopoda, with their trumpet-shaped openings and, similar organs in the worms.

In the little knowledge we have of their embryology, the strongest proofs exist of their affinity with the worms. Lacaze-Duthiers figures the embryo of Thecidium, and it is a little animal with four segments. Fritz Müller figures an early stage of Discina, and we have recalled to us a positive articulate and worm-like character. From the body of this embryo, prominent bristles project. Smitt figures the same in the embryo of Lepralia, wherein he describes six bristles that appear locomotive; and Claparède figures the embryo of Nerine, a worm, in which we find similar bristles projecting from the body. In this connection it is interesting to note that in the winter eggs, or statoblasts, of Polyzoa we have a relation to similar characters among the lower crustacea, the ephippia of Daphnia, and the winter eggs of Rotifers, for example.

Leuckart places the Polyzoa with the worms, and the close affinity of the Polyzoa with the Brachiopoda is now freely admitted, and we now recall those peculiar worms, or early stages of them, which so strongly resemble in almost every essential point of their structure the hippocrepian Polyzoa.

As many of the foregoing points need ample illustration, and as the writer has in preparation a memoir on the subject, he will now only call attention to the facts supporting these views, evolved from the study of living Lingulæ. It is but justice to state that six months previous to the observations made on Lingula, he had come to conclusions herein expressed, and had freely argued it with his colaborators.

He saw the necessity of examining Lingula, however, before advancing these views, and for this sole purpose had visited North Carolina in company with Dr. A. S. Packard, jr., who with his observations on the worms and crustacea of that region yet found time to follow the writer, step by step, in his studies of Lingula, and was deeply impressed by the disclosures there made. His sincerest gratitude is due Dr. Elliott Coues, U. S. A., and Major Joseph Stewart, U. S. A., commandant at Fort Macon, North Carolina, for their constant aid and sympathy in furtherance of the object of his visit there.

After nearly a week's fruitless search, Lingulæ were found in a sand shoal, left at low tide. They were found buried in the sand. The peduncle, which was about six times the length of the shell, being encased in a *sand tube* differing in no respect from the sand tubes of neighboring annelids. In many instances the peduncle was broken in sifting them from the sand, yet the wound was quickly healed and a new sand-tube promptly formed. When placed on the surface of the sand they were noticed to move quite freely, by the sliding motion, in all directions, of the dorsal and ventral plates, aided at the same time by the rows of setæ or bristles, which swung back and forth like a galley of oars, leaving a peculiar track in the sand.

The peduncle was hollow, and the blood could be seen coursing back and forth in its channel. It was distinctly and regularly ringed, and presented a remarkably worm-like appearance. It had layers of circular and longitudinal muscular fibre, and coiled itself in numerous folds

or unwound at full length. It was contractile, also, and quickly jerked the body beneath the sand when alarmed.

But the most startling discovery in connection with this interesting animal was the fact, that its blood was *red*. This was strongly marked in the gills, which were found in the shape of a series of rows of simple lamellæ, hanging from the internal surface of the mouth; thus proving the correctness of Vogt's observations from alcoholic specimens. At times the peduncle would become conjested, and a deep rose blush was markedly distinct. The sexes were distinct.

The writer believes the Brachiopods to be true articulates, having certain affinities with the crustacea, but properly belonging to the worms, coming nearest the tubicolous annelids. They may better be regarded as forming a comprehensive type, with general articulate features. Possibly they have affinities with the mollusks, through the homologies pointed out by Allman as existing between the Polyzoa and Tunicates.

It is interesting to remember that Lingula, though one of the earliest animals created, has yet remained essentially the same through all geological ages to the present time. — EDWARD S. MORSE.

Fig. 76. Fig. 77. Fig. 78.

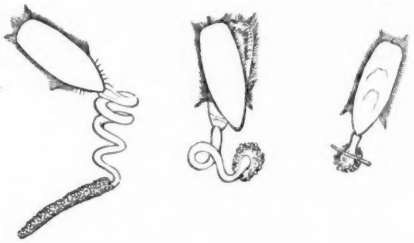


Fig. 76. Peduncle perfect, retaining a portion of the sand tube.
Fig. 77. Showing the valves in motion; the peduncle broken and new sand case being formed.
Fig. 78. Peduncle broken close to body and sand case being formed.

THE RUBY CROWNED WREN. — In reply to Mr. Allen's question, I may state positively that, according to my experience, the adult fertile female is "ruby-crowned" like the male. She is perhaps a trifle smaller, not quite so brightly colored, and with the flame-colored patch possibly of a little less extent; but she cannot be distinguished from the male with certainty, except on dissection, and even then it is not always easy to determine from slight inspection, unless the organs are enlarged in functional activity. The barren or sickly female may possibly not acquire the ornament. Birds of both sexes lack it for at least a year; whether they breed or not with plain heads I do not know. These come along in spring in the rear of the mature birds; they are most abundant at the time when the latter are about leaving. — ELLIOTT COUES.

GEOLOGY.

Geological Survey of Iowa. — The legislature of this state has discontinued the survey which was being so ably conducted by Dr. C. A. White. This seems inexplicable in a state which must necessarily be very largely benefited by the exploration and discovery of its natural resources. Legislatures, however, are not governed by the same rational laws of self interest which actuate private corporations and individuals. Though single mining and manufacturing companies consider it necessary to employ an engineer or a chemist, the legislatures are far too poor or too anxious about the next election to pay any attention to the development of the natural resources and mining interest of the state. Provision has been made, however, for the publication of the State Geologist's Report, which is to be completed in the same style as the Illinois Geological Survey.

New Fossil Turkey. — At the meeting of the Philadelphia Academy of Natural Sciences, March 8th, Professor O. C. Marsh of Yale College, exhibited a number of fossil remains from the Post-tertiary deposits of Monmouth county, New Jersey, which indicate a new and distinct type of birds, closely related, apparently, to the turkey, and not unlikely the progenitors of the existing species. The specimens shown were portions of three skeletons, of different ages, which belonged to birds about the size of the common wild turkey (*Meleagris gallopavo* Linn.), although proportionally much taller. The tibiæ and tarso-metatarsal bones were, in fact, so elongated, as to resemble those of wading birds. These interesting remains were referred provisionally by Professor Marsh to the genus *Meleagris*, and the species they represent was named *Meleagris altus*.

MICROSCOPY.

Circulation of the Latex in the Laticiferous Vessels. — Within a few days I have repeated some experiments (first made more than fifteen years since) upon the circulation of the latex in the laticiferous vessels of the leaf of *Chelidonium majus*, to which I desire to call attention.

Before detailing these experiments it ought, perhaps, to be stated that Amici, Dutrochet and Mohl deny any visible motion in them except such as is the result of injury; while Schleiden says "that in the uninjured vessels, the motion of the latex can very seldom be successfully shown;" even in *Chelidonium majus* it is only occasionally possible, and then presents great optical difficulties.

Now, I find, by potting a young plant of this kind, and placing any young leaf between two strips of glass (upon which a drop of glycerine has been put) in such a manner as to bring the under side of the leaf up-

permost on the stage of the microscope, so as to throw the strong reflected sunlight upon it from the mirror below, that;

First, there is occasionally either a nearly total want of motion or only a very slow one of the colored granules, or at times a very rapid motion of the particles to be seen, running from right to left, if the vessel happens to run horizontally on the stage, or toward me if the vessel runs from the outer to the inner border of the stage, and

Secondly, that while *watching* the circulation as seen through the lenses in the reflected sunlight, if I move the diaphragm from left to right, so as to make the shadow enter upon the right of the field of view, a brisk circulation (no matter how quiet it had been before) is instantly witnessed, which appears to be changed in direction as we move the diaphragm back again; and that the direction of the *circulation* can thus be *changed* at *will* by the *interception of the sunlight*. This same result can also be witnessed by the passage of clouds between the sun and mirror. The actual direction in the plant is *from* the apex of the leaf *in sunlight* and *toward* it in the shade. This *change in direction* is *so rapid* when produced by the *shadow* of *fast flitting* clouds across the sun's disc that it would seem that the change of temperature could hardly be felt by the plant, it certainly could not be by an ordinary thermometer; but a heated body properly placed will quicken the circulation, as will cold retard it. If I mistake not we have here a fine demonstration of the conversion of light into heat by its passage through the vegetable tissues, and of heat into motion by its action upon the laticiferous vessels.

Prof. Balfour in the Article Botany, "Ency. Brit.," says that in plants with milky and colored juices evident movements have been perceived, and mentions the calyx leaves of *Chelidonium majus*, as also the India-rubber plant, the gutta-percha tree, the dandelion, and the *Euphorbia;* and through your journal, should you think this article worth insertion, I would ask assistance in the examination of this interesting subject. By mixing a little of the colored juice with alcohol, and adding a little water, it will be seen that the motion of the liquids in the vessels cannot be the result of evaporation. And that it is not an ocular illusion may be argued from the fact that three independent observers witnessed the changes of motion as above described. — H. C. PERKINS, M. D., *Newburyport.*

Note, May 12. I have just examined the circulation of the latex in the laticiferous vessels of *Leontodon taraxacum* under the same circumstances as that of *Chelidonium* and am pleased to find precisely the same results. — H. C. P.

DOES BOILING DESTROY GERMS? — This question cropped up in the course of the Pasteur and Pouchet controversy on Heterogeny, and it appeared that there are some germs that are not destroyed by boiling, but which require a temperature some degrees (10° or 12°, we believe) above boiling. This is another simple problem for microscopists. — *Monthly Microscopical Journal.*

ANTHROPOLOGY.

ARCHÆOLOGICAL IMPOSTURES.— To *hoax* is eminently an American proclivity or habit, a kind of friskiness not without a tinge of mischief, and always reckless, which pervades our society far and wide, and which is gratified by creating what is called "a sensation." Sometimes there is a sinister or selfish motive behind, and a deliberate imposture is practiced with the view to pecuniary advantage. Of this the "Aztec children" and the "Onondaga giant" are clear examples. The latter fraud, it is to be hoped, is defunct; the former flourished for years after it had been thoroughly exposed.

I have hunted down a score or more of these frauds on popular credulity, only to find a dozen others springing up in the place of each one slaughtered. Skeletons of giants resolving themselves into bones of the mastodon; great jawbones fitting over the faces of common mortals — just as though two spoons of equal size could not fit into or over each other—inscribed plates, such as of mica discolored by infiltrations of iron, etc., etc., *ad nauseam*. Not long ago I received a letter from a *savant* in Vienna, regretting that I had not given "a full and particular account' of the extraordinary vault, with its statues and inscriptions that had been discovered in the rocks of the Palisades of the Hudson, and hoping that I would prevail upon some competent western correspondent to make a farther careful examination of the recently discovered ancient tunnel under the Mississippi River, opposite St. Louis! During the last summer I received a note from a gentleman, whose name is not unknown as a north-western explorer, enclosing a slip from a Kansas paper, giving an account of the discoveries of "Professor Henry L. Scott, LL. D., of Georgetown, Ky.," near Evanstown, Shelby Co., Utah, in one of the cañons of Rear River in the Uintah Mountains. I quote from the article:

"Having secured the help of some half dozen men, Professor Scott immediately directed his course towards the South, where a bastard canon starts out from one of the Uintah spurs. Fortunately he had with him a half-breed who could converse with the Shoshones, who range all through that section, and through the interpretor he learned from Wa-pa-on-ta (Stag), a sub-chief of the Shoshones, that about fifteen miles from Evanston was a mound of extraordinary dimensions. The Professor immediately repaired to the place, and to his great gratification discovered a tumulus of as fair and positive proportions as any described by Squier and Davis. He immediately commenced the work of excavation, and in three days had the inexpressible pleasure of laying bare what was certainly a vault. He found a cavity about eight feet long, three wide, and four deep. Its bottom, sides and ends were made of triangular shaped stones, evidently quarried from the red granite of the Wasatch range. There was no top or covering to the vault, but from the nature and color of the earth immediately over it, the Professor thinks that an arch of burned clay had been used. But one skeleton was found, which on exposure, immediately crumbled into dust; it appeared to indicate that of a man not over five feet ten inches. The bones lay east and west — the skull east. At the foot, and apparently between the feet, was found an ordinary-shaped earthen pot, with a capacity perhaps of half a gallon, cone-shaped, and without any mark or engraving whatever on it. Along the left side lay an iron bracelet with a spring clasp, perfectly preserved. On each side of the skull were two medicine stones, shaped like a cigar, full of holes, and of half-pound weight.

The stones were very similar to Tennessee marble or Scotch granite. On the right side of the skeleton the Professor found a silver plate about the size and exactly the shape of an artist's palette. No mark whatever was distinguishable on this piece, but it is of the purest silver. It may have been used as a shield, though the Professor inclines to the belief that it was a "charm," and that the skeleton was that of some medicine man or priest."

I replied to my correspondent that I thought the whole story a "hoax," but if it would please him would soon find out if it were or not. I accordingly addressed a letter to the editor of the paper in which the article originally appeared, asking him on what authority the publication was made. He answered that it had been written by a sub-editor (giving his name) who, however, had left his employ, but to whom he would forward my letter. A few days ago I secured a note from the sub-editor aforesaid, in which he says:

"To be frank with you, 'Explorations in Utah' was a *sensation*, written to offset the forthcoming report of 'Professor Powell in the Colorado Canons,' and Colonel Samuel Adams' in Colorado,' both of which have since appeared. From personal observation in the region mentioned, I know both reports to be very erroneous."

I should perhaps mention that "Professor Scott's" explorations were alleged to have been undertaken under the belief that the race of the mound builders of the Mississippi Valley had migrated to Mexico and Central Mexico, and that traces of their transit might be found on the way. — E. G. SQUIER.

ANSWERS TO CORRESPONDENTS.

T. Dupuy, M. D. — Your specimens though inconveniently small for determination, are: 1, *Polypodium incanum*; 2, *Aspidium patens*; 3, *Parmelia perlata* variety *olivetorum*; 4, *Ramilina fraxinea*; 5, *Parmelia speciosa* variety *gramelifera*. Southern species of lichens and ferns are very acceptable. Send along some more. Your remarks upon the *Tillandsia usneoides* are interesting; may we hear more from you on the habits of the plants of your vicinity? — J. L. R.

BOOKS RECEIVED.

Annual Meteorological Synopsis. By J. B. Trembley, M.D., Toledo, Ohio. Pamph. 1870.

The One Hundred Dollar Prize Essay on the Cultivation of the Potato. By D. H. Compton. 8vo. pamph. Illustrated. Orange Judd & Co. New York, 1870. (25 cts).

The Geological Survey of Ohio, its Progress in 1869. Report of an Address delivered to the Legislature of Ohio, February 7, 1870. By J. S. Newberry, Chief Geologist. 8vo, pamph. 1870.

Narrative of a Bear Hunt in the Adirondacks. Read before the Albany Institute, January 18, 1870. By Verplanck Colvin. 8vo, pamph. J. Munsell. Albany, 1870.

Proceedings Academy of Natural Sciences of Philadelphia. No. 4. December, 1869.

Discourse on the Life and Character of George Peabody. By S. T. Wallis. Peabody Institute of Baltimore. 8vo. pamph. 1870.

Journal of the Queckett Microscopical Club. No. 10. April, 1870. 8vo. Plates. London. R. Hardwicke, for the Club. (1s. a number.)

Alaska and its Resources. By W. H. Dall. Large 8vo. Cloth. 628 pages. Many illustrations and Map. Boston, 1870. Lee & Shepard. $7.50.

First Annual Report of the Geological Survey of Indiana, made during the year 1869. By E. T. Cox, State Geologist, assisted by Messrs. Bradley, Haymond and Levette. 8vo, cloth. pp. 240. 4 maps. Indianapolis, 1869.

On Existing Remains of the Gare-Fowl (Alca impennis). By Alfred Newton. [From "The Ibis" for April, 1870.]

Contributions to the Theory of Natural Selection. A Series of Essays. By Alfred Russel Wallace. pp. 384. 12mo. cloth. London and New York. 1870. Macmillan & Co.

The Naturalist's Guide in Collecting and Preserving Objects of Natural History, with a Complete Catalogue of the Birds of Eastern Massachusetts. By C. J. Maynard. Illustrated. pp. 170. 12mo, cloth. Boston, 1870. Fields, Osgood & Co. [$2.00.]

Annals of the Lyceum of Natural History of New York. Vol. ix. No. 10. April, 1870.

Naturalist's Note Book. April and May, 1870. London.

Universal Decimal Weight, Measure and Coinage Association. Circular No. 1. May, 1870.

On the Pre-Carboniferous Floras of North-eastern America, with special reference to that of the Erian (Devonian) Period. Abstract of the Bakerian Lecture. By J. W. Dawson. [From Proceedings Royal Society. London, 1870.]